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Ontario

Air Quality in Ontario

1996

A concise report on the state of air quality in the province of Ontario

Message from the Honourable Norman W. Sterling

Minister of the Environment

Improving our air quality remains a top priority for the Government of Ontario. As Minister of the Environment, I am determined to protect our common right to breathe air that is safe and clean. That's a big challenge, but we are making steady progress towards meeting it.

This is the 26th report on the state of air quality in Ontario.

Since our first report was published in 1971, we have documented a consistent improvement in the quality of the air we breathe. This improvement, in an era of considerable population growth, shows we are making real progress in pollution control and in the fight for cleaner air.

Between 1987 and 1996, concentrations of carbon monoxide, nitrogen dioxide and total reduced sulphur declined. There was also a decline in Ontario emissions of carbon monoxide, nitrogen oxides, sulphur dioxide and volatile organic compounds.

During 1996, Ontario's Air Quality Index reported air quality readings in the good to very good range 95 per cent of the time.

However, while we have seen considerable improvement, we know that much more needs to be done. That's why we are taking aggressive action to ensure that Ontario's air quality continues to improve. We are placing special emphasis on ozone, fine particles and the other compounds that contribute to smog.

Under the government's Drive Clean program, which begins in spring '99, cars, vans and light duty trucks in areas with high smog levels will have to pass a vehicle emissions test. Heavy duty trucks and buses province-wide will also be tested. Vehicles that don't pass will have to be repaired and retested.

We are currently updating air quality standards and regulations to make them better, clearer and stronger. This includes a new, tough standard for inhalable particles, a key ingredient of smog.

Gasoline producers are now required to make less polluting blends of gasoline during the summer, which has resulted in 18,000 fewer tonnes of smog-causing compounds annually.

Ontario's Smog Plan brings together a broad coalition of industries and groups determined to reduce smog-causing emissions by 45 per cent by 2015.

We are also building strong environmental protection measures into the design of a competitive electricity market for Ontario. These measures will be aimed at reducing smog, acid gas and greenhouse gas emissions. All electricity generators wishing to supply power to Ontario will have to meet our tough standards.

All these initiatives will help improve our air quality. And to stay on top of this priority issue, we are investing in better monitoring tools.

We have spent $3 million since 1995 to make sure Ontario has the most modern and best equipped air monitoring network in North America. We also have a new air monitoring bus to monitor smog-causing pollutants and assess their effects anywhere in the province.

Initiatives such as Partners in Air – a partnership teaching young people about air quality – and the Smog Rover – a mobile van that identifies polluting vehicles on Ontario roads – are educating the public on the need to improve the quality of our air.

And, recognizing that half the pollution that causes smog comes from the U.S., we have started a program of international education and team building. In 1997, I met with my counterparts in 11 states and urged them to toughen their air quality regulations to deal with trans-boundary pollution. We are continuing to work with those states on ways to meet this common challenge.

With these initiatives, Ontario is making progress in protecting our air and improving its quality. We intend to continue that progress, because it's the right thing to do for the air we breathe.

December 1998

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Report Highlights

Between 1987 and 1996, air quality in Ontario continued to improve. Average provincial levels of total reduced sulphur compounds were reduced by 67 per cent, carbon monoxide by 27 per cent and nitrogen dioxide by five per cent.

- In 1996, Ontario's air quality index reported good to very good air quality readings 95.3 per cent of the time.
- Three air quality advisories were called in 1996, covering a period of five days. This is down from the six advisories called in 1995 that covered a total of 11 days.
- Measured concentrations for more than 20 volatile organic compounds were well below existing provincial criteria.
- On an international basis, using the most recent available data, Toronto's air was better than most of the cities with which it was compared. It was one of the 10 best for low levels of sulphur dioxide, carbon monoxide and inhalable particles. For ozone and nitrogen dioxide, it was better than 50 per cent of the cities surveyed.
- Ground-level ozone and inhalable particles – the major components of smog – were the pollutants that most often exceeded the provincial air quality criteria. More than 50 per cent of the ozone and a considerable amount of inhalable particles were caused by air pollution from the U.S.

Introduction

Since 1971, the Ministry of the Environment has been monitoring air quality in Ontario and using this information to:

- inform the public about outdoor air quality in real time;
- provide a pollution episode warning and control mechanism for public health protection;
- assess Ontario's air quality and evaluate trends;
- identify areas where criteria are exceeded and identify the origins of pollutants;
- provide the basis for air policy development;
- provide quantitative measurements to enable abatement of specific pollutant sources;
- determine the levels of pollutants from U.S. sources and their effects on Ontario; and
- provide air quality data for researchers linking environmental and human health effects to air quality.

Air quality is measured on the basis of emissions of contaminants into the atmosphere from both human and natural activity, and from their atmospheric interactions. Local air quality is influenced by emissions from motor vehicles and other transportation sources, industrial sources, and meteorological and topographical conditions.

Distant sources are significant contributors to local air quality for contaminants that undergo long-range transport and transformation, such as ozone, trace metals and the components of acid rain.

Table 1.0 shows the relationship between monitored air pollutants and current air issues. Individual contaminants can have impacts (usually adverse but sometimes beneficial) on a number of air issues at the same time. Such interactions require integration of air issues in order to see the complete picture.

This report, 26th in a series, summarizes the state of air quality in Ontario in 1996. It covers measured levels of ozone (O_3), particles and other principal contaminants such as sulphur dioxide (SO_2) , nitrogen dioxide (NO_2), carbon monoxide (CO) and total reduced sulphur (TRS) compounds. Results are also presented for the measurement of a number of airborne organic compounds for 1996. In addition, the report summarizes the 1996 Air Quality Index and Air Pollution Index statistics from the real-time air quality index information system.

In the past, an emphasis has been placed upon monitoring for sulphur dioxide and total suspended particles. As significant reductions have been achieved in their levels over time, increased emphasis is now being directed to ozone and inhalable (PM_{10}) and respirable ($PM_{2.5}$) particles for which scientific evidence suggests significant health impacts.

Ontario continues to benefit from one of the most comprehensive air monitoring systems in North America. The network is designed to measure air quality at more than 200 sites across the province. This network undergoes constant maintenance to ensure a high standard of quality control. Continuous real-time air quality data are reviewed, assessed and validated constantly. Action is taken immediately to correct anything that may affect the validity of the data. These measures ensure that the ambient air monitoring data are valid, complete, comparable, representative and accurate. As a result, for 1996 the network had 94.6 per cent valid data out of approximately four million data points. With this data, Ontario can make informed decisions about what needs to be done to protect our environment and improve our air quality.

Table 1.0

Linkages between air pollutants and air issues

	Smog	Global Warming	Urban Air Quality	Acid Deposition	Health	Aesthetics
Ozone	yes	yes	yes	yes	yes	
Sulphur Dioxide	yes	yes	yes	yes	yes	yes
Carbon Monoxide			yes		yes	
Oxides of Nitrogen	yes	yes	yes	yes	yes	yes
Volatile Organic Compounds	yes	yes	yes		yes	yes
Toxic Organics			yes		yes	
Particles	yes	yes	yes	yes	yes	yes
Total Reduced Sulphur Compounds			yes		yes	yes

Chapter 1

Principal Contaminants

The principal contaminants considered in this report include O_3, TSP, PM_{10}, SO_2, NO_2, CO and TRS. They are also commonly referred to as criteria pollutants because Ontario has established ambient air quality criteria (AAQC) based on health and/or environmental effects. The AAQCs are used as yardsticks for measuring the success of our programs. Most of the trend information presented in subsequent chapters of this report is based on two types of data: direct

Table 1.1

Overview of criteria pollutants

Pollutant	Characteristics	Sources	Ontario Criteria	General Health Effects	General Ecological Effects
Ozone (O_3)	A colorless gas with a strong smell. Major component of summer smog.	Ozone is not emitted directly into the atmosphere. It is produced by photochemical action on nitrogen oxides and volatile organic compounds.	1 h average 80 ppb	Irritation of the lungs and difficulty in breathing. Exposure to high concentrations can result in chest tightness, coughing and wheezing.	Damage to agricultural crops, ornamentals, forests and natural vegetation.
Total Suspended Particles (TSP)	Particles of solid or liquid matter that stay suspended in air in the form of dust, mist, aerosols, smoke, fume, soot, etc. Size range 0.1-100 microns.	Industrial processes including combustion, incineration, construction, metal smelting, etc. Also motor vehicle exhaust and road dust. Natural sources such as forest fires, ocean spray and volcanic activity.	24 h average 120 µg/m³ 1 y average 60 µg/m³	The smaller the particle the greater the effect on health. Significant effects for people with lung disease, asthma and bronchitis. See PM_{10} below.	Damage to vegetation, deterioration in visibility and contamination of soil.
Inhalable Particles (PM_{10})	Same as TSP except size range of particles is less than 10 microns.	Same as TSP	24 h average 50 µg/m³	Increased hospital emissions and premature deaths.	Same as TSP.
Total Reduced Sulphur (TRS)	Offensive odors similar to rotten eggs or cabbage	Industrial sources include steel industry, pulp and paper mills and refineries. Natural sources.	1 h average 27 ppb (kraft pulp mill)	Not normally considered a health hazard. They are the primary cause of odors.	
Sulphur Dioxide (SO_2)	Colorless gas with a strong odor similar to burnt matches.	Electric utilities and non-ferrous smelters . Also primary metal processing, iron ore smelters, pulp and paper, petroleum refineries, etc.	1 h average 250 ppb 24 h average 100 ppb 1 y average 20 ppb	Breathing discomfort, respiratory illness, aggravation of existing respiratory and cardiovascular disease. People with asthma, chronic lung or heart disease are most sensitive to SO_2.	Leads to acid deposition, which causes lake acidification, corrosion and haze. Damage to tree leaves and crops.
Nitrogen Dioxide (NO_2)	Gas with a pungent and irritating odor.	Automobiles, thermal power plants, incineration, etc. Natural sources include lightning and soil bacteria.	1 h average 200 ppb	Increasing sensitivity for people with asthma and bronchitis.	Leads to acid deposition: adverse effect on vegetation.
Carbon Monoxide (CO)	Colorless, odorless, tasteless and poisonous gas.	Major source is transportation sector; i.e., road vehicles, aircraft and railways.	1 h average 30 ppm 8 h average 13 ppm	Impairment of visual perception, work capacity, learning ability and performance of complex tasks.	

measurement of ambient air concentrations and estimates of air emissions based on best available information. For additional information on air emission estimates, please refer to MOE's Fast Response Emission Document (FRED), version 4.

A brief description of the criteria pollutants according to their characteristics, sources and effects is provided below and summarized in Table 1.1 along with the current Ontario ambient air quality criteria.

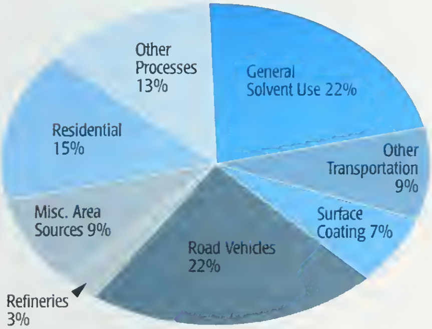
Ground-level ozone

Characteristics: O_3 is a colorless, odorless gas at ambient concentrations and is a major component of smog.

Sources: Ground-level ozone is not emitted directly into the atmosphere. It results from chemical reactions between NO_X and VOCs in the presence of sunlight. High levels typically occur from May to September, between noon and early evening. Figure 1.1 shows estimates of Ontario's VOC emissions caused by human activity, by sector. Transportation modes account for approximately 31 per cent of VOC emissions. Owing to the large forested area in Northern Ontario, biogenic emissions of certain VOCs are significant, approximately three times those from sources caused by human activity. The sources of NO_X are listed below.

Figure 1.1

Ontarios VOC emissions by sector. (Emissions from human activity, 1996 estimates)



Effects: O_3 irritates the respiratory tract and eyes. Exposure to high levels of O_3 results in chest tightness, coughing and wheezing. People with respiratory and heart problems are at a higher risk. Ozone has been linked to increased hospital admissions and premature death. Ozone causes agricultural crop loss each year in Ontario and noticeable leaf damage in many crops, garden plants and trees.

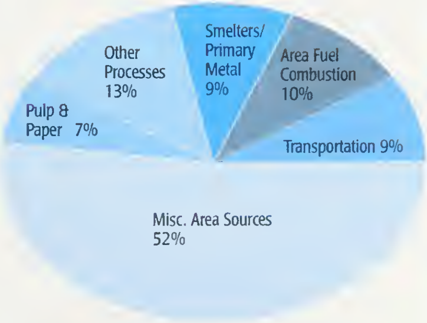
Particles

Characteristics: Particles in the atmosphere consist of either solid particles or fine liquid droplets. They include aerosols, smoke, fumes, dust, fly ash and pollen. Composition varies with place and season. Particles in the atmosphere have been characterized according to size mainly because of the different health effect from particles of different diameters. Particles with diameters less than 100 microns are classified as total suspended particles (TSP). Particles less than 10 microns and 2.5 microns in diameter are defined as inhalable particles (PM_{10}) and respirable particles ($PM_{2.5}$), respectively. The smaller the particle size the further the particle will penetrate into the lungs.

Sources: The majority of particle emissions from human activity fall into the size range that is classified as TSP (Figure 1.2). PM_{10} sized particles (Figure 1.3) are emitted from industrial sources such as fuel combustion, energy production, incineration, construction, mining, metal smelting and processing. In the urban airshed, motor vehicle exhaust, residential wood combustion and road dust are the major sources. Natural sources include wind-

Figure 1.2

Ontario particle emissions by sectors. (Emissions from human activity, 1996 estimates)

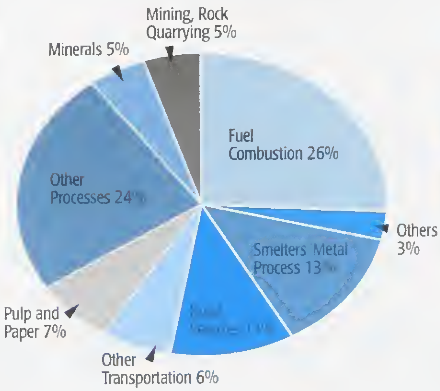


[1] Emissions from road dusts, construction, agriculture, etc., are not included.

[2] Emissions from open sources from the smelters are not available.

Figure 1.3

Ontario PM_{10} emissions by sectors. (Emissions from human activity, 1990 estimates)

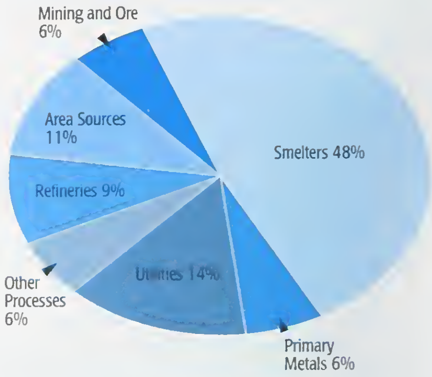


[1] Emissions from road dusts, construction, agriculture, etc. are not included.

[2] Emissions from open sources from the smelters are not available.

Figure 1.4

Ontario sulphur dioxide emissions by sectors. (Emissions from human activity, 1996 estimates)



blown soil, forest fires, ocean spray and volcanic activity. $PM_{2.5}$ material is primarily formed from chemical reactions in the atmosphere and through combustion.

Effects: The greatest effect on health is from particles 10 microns or less in diameter (PM_{10}), which can aggravate bronchitis, asthma and other respiratory diseases. These small particles have been linked to increased hospital admissions and premature death. People with asthma, cardiovascular or lung disease, as well as children and elderly people, are considered to be the most sensitive to the effects of particles. Particles are also responsible for corrosion, soiling, damage to vegetation and visibility reduction.

Sulphur dioxide (SO_2)

Characteristics: SO_2 is a colorless gas. It smells like burnt matches. It can be oxidized to sulphur trioxide, which in the presence of water vapor is readily transformed to sulphuric acid mist. SO_2 can be oxidized to form acid aerosols. SO_2 is a precursor to sulphates, which are one of the main components of respirable particles in the atmosphere.

Sources: Approximately 62 per cent of the SO_2 emitted in Ontario in 1996 came from smelters and utilities. Other industrial sources include iron and steel mills, petroleum refineries, and pulp and paper mills. Small sources include residential, commercial and industrial space heating (Figure 1.4).

Effects: Health effects caused by exposure to high levels of SO_2 include breathing problems, respiratory illness, changes in the lung's defenses, and worsening respiratory and cardiovascular disease. People with asthma or chronic lung or heart disease are the most sensitive to SO_2. It also damages trees and crops. SO_2, along with NO_X, are the main precursors of acid rain. This contributes to the acidification of lakes and streams, accelerated corrosion of buildings and reduced visibility. SO_2 also causes formation of microscopic acid aerosols, which have serious health implications as well as contributing to climate change.

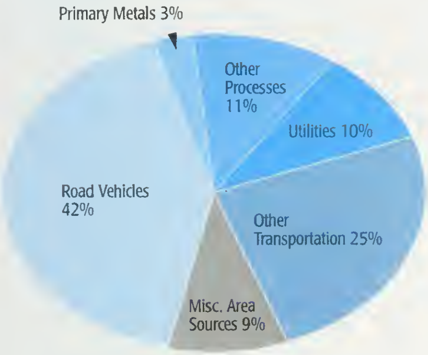
Nitrogen dioxide (NO_2)

Characteristics: NO_2 is a reddish-brown gas with a pungent and irritating odor. It transforms in the air to form gaseous nitric acid and toxic organic nitrates. NO_2 also plays a major role in atmospheric reactions that produce ground-level ozone, a major component of smog. It is also a precursor to nitrates, which contribute to increased respirable particle levels in the atmosphere.

Sources: All combustion in air produces oxides of nitrogen (NO_X), of which NO_2 is a major component. Approximately 67 per cent of NO_X comes from the transportation sector in Ontario (Figure 1.5). A large part of the remaining 33 per cent comes from power generation, primary metal production and incineration. Natural sources of NO_X include lightning and the aerobic activity of soil bacteria. These natural sources, however, are small compared to emissions caused by human activity.

Figure 1.5

Ontario nitrogen oxides emissions by sectors. (Emissions from human activity, 1996 estimates)



Effects: NO_2 can irritate the lungs and lower resistance to respiratory infection. Sensitivity increases for people with asthma and bronchitis. NO_2 chemically transforms into nitric acid and, when deposited, contributes to lake acidification. NO_2, when chemically transformed to nitric acid, can corrode metals, fade fabrics and degrade rubber. It can damage trees and crops, resulting in substantial losses.

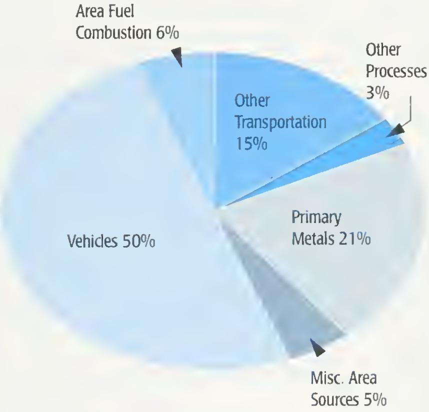
Carbon monoxide (CO)

Characteristics: CO is a colorless, odorless, tasteless and poisonous gas produced primarily by incomplete burning of fossil fuels.

Sources: The transportation sector accounts for 65 per cent of all CO emissions from human activity in Ontario (Figure 1.6). A large part of the remainder comes from primary metal producers (21 per cent) and from fuel combustion in space heating and industrial processes (six per cent).

Figure 1.6

Ontario carbon monoxide emissions by sectors. (Emissions from human activity, 1996 estimates)



Effects: CO enters the blood stream and reduces oxygen delivery to the organs and tissues. People with heart disease are particularly sensitive. Exposure to high levels is linked with impaired vision, work capacity, learning ability and performance of difficult tasks.

Total reduced sulphur compounds (TRS)

Characteristics: TRS compounds produce offensive odor similar to rotten eggs or cabbage.

Sources: Industrial sources of TRS include the steel industry, pulp and paper mills, refineries and sewage treatment facilities. Natural sources include swamps, bogs and marshes.

Effects: TRS compounds are not normally considered a health hazard. They are, however, a primary cause of odors.

Chapter 2

Ozone in Ontario

Ground-level ozone is a gas formed when nitrogen oxides and volatile organic compounds react in the presence of sunlight. Ground-level ozone is the primary component of smog and is different from the ozone layer high above the earth that protects us from the sun's harmful UV rays. The formation and transport of ozone are strongly dependent on meteorological conditions. In Ontario, elevated concentrations of ground-level ozone are generally recorded on hot, sunny days from May to September between noon and early evening. Significant amounts of ozone and ozone-forming compounds are carried into Ontario from the U.S. During periods of widespread elevated ozone, it is estimated that more than 50 per cent of Ontario's ground-level ozone can be attributed to trans-boundary pollution. Figure 2.1 shows the area from which southern Ontario air arrives during days of widespread elevated ozone levels. Whenever high ozone was recorded, the air mass had resided over the high emission areas of the mid-west U.S and moved into Ontario.

Monitoring results for 1996

Ground-level ozone was monitored at 43 locations during 1996. Highlights of the ozone monitoring results for 1996 are shown in Appendix 1. The lowest annual mean (12.2 ppb) was measured at the Toronto Downtown location while the highest mean (33.5 ppb) was measured at Long Point, a rural site on the northern shore of Lake Erie. Generally, ozone is lower in urban areas because it is removed by reaction with locally emitted nitric oxides.

Figure 2.1
U.S. source regions of trans-boundary ozone

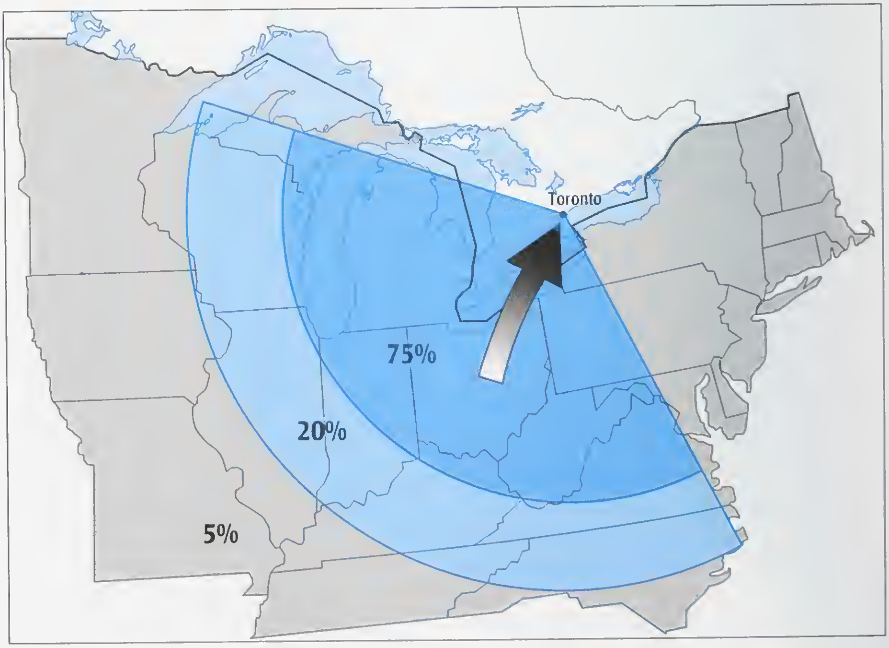
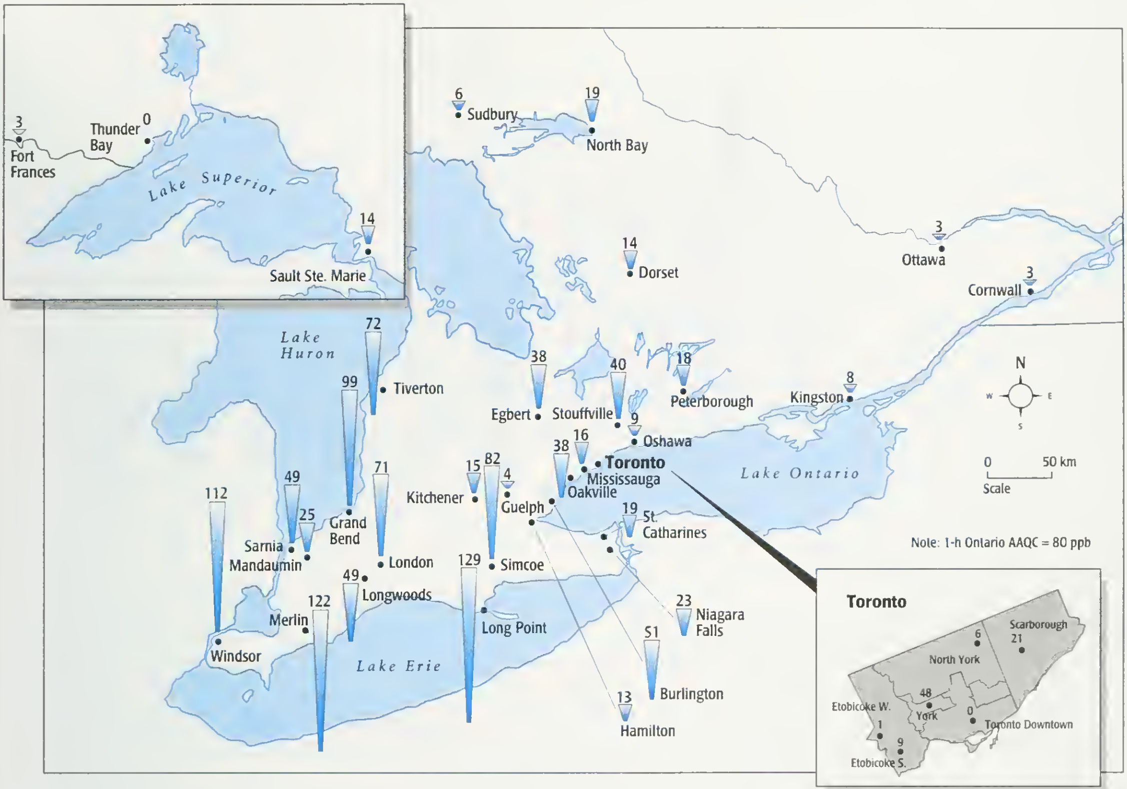


Figure 2.2

Geographical distribution of 1-hour ozone exceedances across Ontario (1996)



Among urban sites, Windsor College recorded both the highest one-hour concentration (116 ppb) and the greatest number of instances of elevated ozone (112) while Sudbury in Northern Ontario recorded the highest annual urban mean (28.1 ppb).

At rural sites, Long Point recorded both the highest one-hour concentration (129 ppb) and the greatest number of instances of elevated ozone (129).

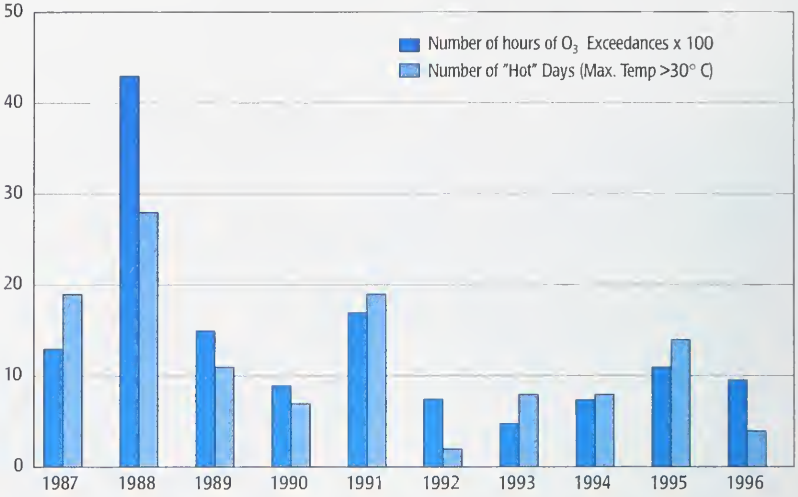
Ground-level ozone is the pollutant that exceeds the provincial ambient air quality criterion (AAQC) most often. In 1996, the Ontario one-hour ozone criterion (80 ppb) was exceeded at 40 of 43 monitoring stations. With the exception of the Toronto Downtown site, all ozone monitoring sites in southern Ontario recorded at least one hour of elevated ozone (above 80 ppb) in 1996. At these levels, people with heart and lung problems are at risk. Sensitive people may have trouble breathing and their health may be affected if they engage in vigorous exercise. Figure 2.2 shows geographical distribution of the number of hours of elevated ozone across Ontario. The higher numbers are found at sites in the southwestern part of the province, along both the eastern shore of Lake Huron and the northern shore of Lake Erie. The seriousness of trans-boundary flow is reflected in the relatively higher levels measured there. As mentioned earlier, more than 50 per cent of provincial ozone levels during widespread ozone episodes are due to long-range transport of ozone and its precursors from neighbouring U.S. states.

Trends

Interpretation of the 10-year ambient ozone trends is complicated by meteorology and emission changes.

Figure 2.3

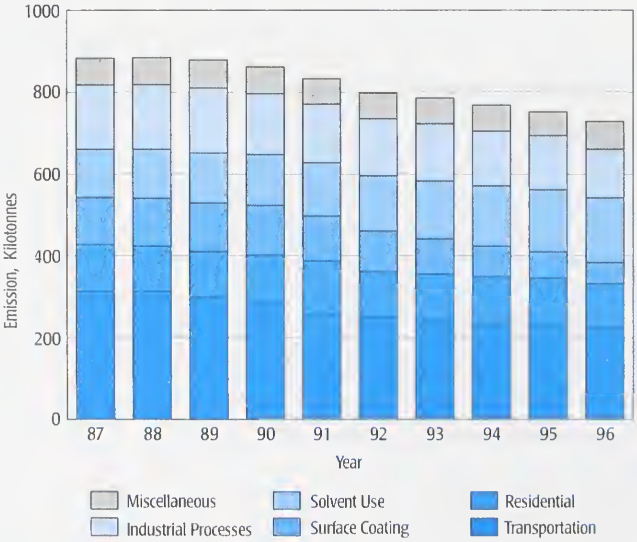
10-year trend for ozone exceedances and "Hot" days (1987-1996)



Note: For 22 ozone sites operated over 10 years

Figure 2.4

Trend for Ontario VOC emission estimates (1987-1996)



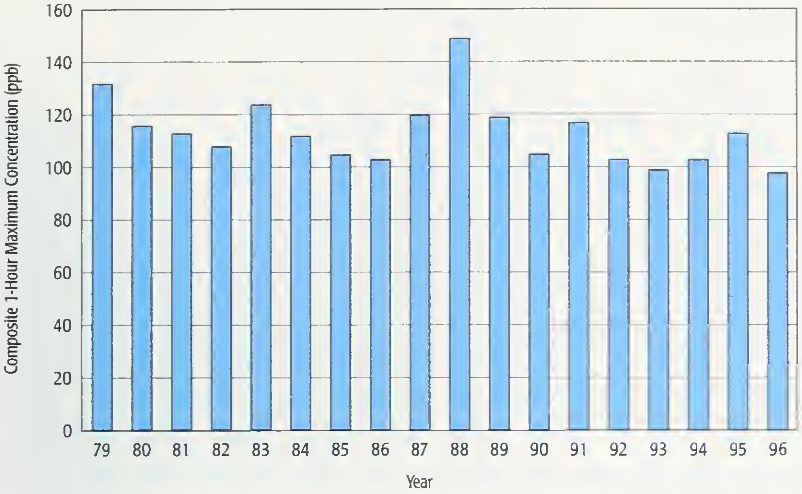
Year to year, ozone levels are strongly influenced by weather. Figure 2.3 shows the distribution of province-wide instances of elevated ozone alongside the number of hot days (days with maximum air temperatures greater than 30 degrees C) for 1987 to 1996. Just as the highest number of one-hour elevated levels in 1988 (4345) are likely attributed in part to the weather (highest number of hot days), so probably the low numbers in 1992 (480) reflect conditions less conducive to production of ground-level ozone (lowest number of "hot" days).

The emissions of VOC show a slight decreasing trend for the overall period 1987 to 1996 and a more pronounced decrease between 1990 and 1996. (Figure 2.4). New vehicle emission standards in the early 1990s contributed to this decreasing trend. Emissions from forest fires and natural sources are not included in this trend; these emissions may be as high as three times the emissions due to human activity.

The introduction of lower gasoline volatility (from 82.8 kPa to 72.0 kPa) beginning in 1989 for the summer months, has resulted in a 1.4 per cent decrease in provincial total VOC emissions in 1996 and an overall 7.8 per cent reduction over the eight-year program period.

Figure 2.5

Long-term trend for 1-hour maximum ozone concentrations (1979-1996)



Note: 22 sites operated over 18 years

The effect of changes in VOC emissions, as a precursor, on ozone production is not obvious from the trend of ozone for 1989 to 1996. However, preliminary analysis indicates a slight decrease in the composite peak one-hour ozone concentrations during the 1989 to 1996 period compared to the 1979 to 1987 period when the gasoline volatility was 82.8 kPa (Figure 2.5). However, we must not lose sight of the meteorological variability factor mentioned earlier, which plays a significant role in ozone formation as shown in the unusually hot summer of 1988.

The trend of the composite annual means for the 22 (15 urban and seven rural) long-term ground-level ozone sites across Ontario from 1979 to 1996 is shown in Figure 2.6. It shows that there has been an increasing trend in the annual means during the period. The composite averaged annual mean over this 18-year period was 21.8 ppb. If we look at the nine-year period 1979 to 1987, there was only one year that exceeded the 18-year average. However, during the second nine-year period 1988 to 1996, every year except one recorded an annual ozone mean higher than the 18-year average. The composite annual ozone mean in 1996 was 15 per cent higher than in 1979. Composite annual ozone means show an increasing trend at both urban and rural locations.

International perspective

Internationally, Toronto ranks in the "middle of the pack" when it comes to one-hour maximum ozone concentrations, 18th out of 36 cities (Figure 2.7). The highest one-hour concentrations during 1995 were recorded at Sao Paulo (389 ppb) and Mexico City (349 ppb). Of the 36 cities reporting, 16 exceeded the United States standard (120 ppb) while 33 cities exceeded the more restrictive Ontario one-hour criterion (80 ppb). Of the 19 cities with populations above 2 million, Toronto recorded the 12th highest one-hour concentration (122 ppb). It should be noted that hourly values of ozone vary from year to year, depending on factors such as precursor emissions and weather.

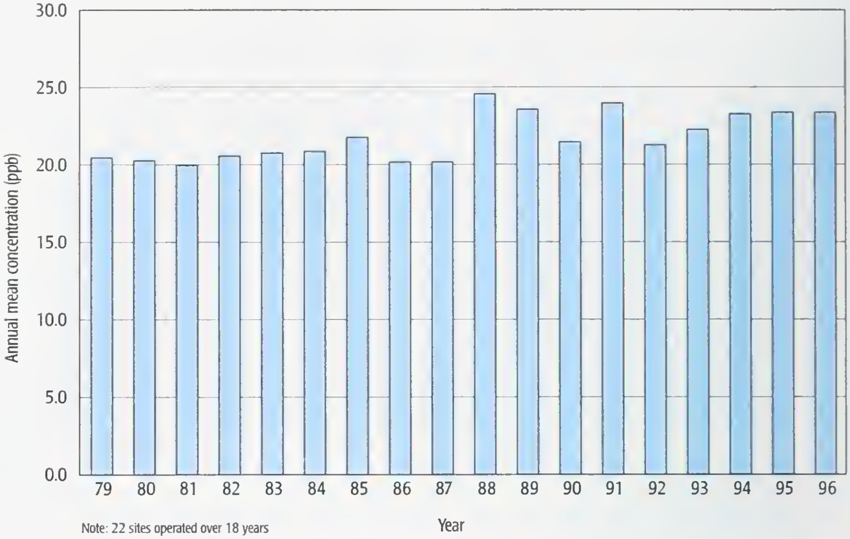
Air quality advisories

Initiated in the late spring of 1993 as a joint effort between the Ministry of the Environment and Environment Canada, air quality advisories are issued to the public when elevated pollution levels are forecast due to ground-level ozone. This program builds on Ontario's Air Quality Index (AQI) program, which is discussed in Chapter 5.

These advisories are based on provincial AQI forecasts for ground-level ozone. They are issued regionally in the late afternoon, the day before

Figure 2.6

Long-term trend for mean annual ozone levels (1979-1996)



Note: 22 sites operated over 18 years

Figure 2.7

Maximum 1-hour ozone concentrations in selected world cities (1995)

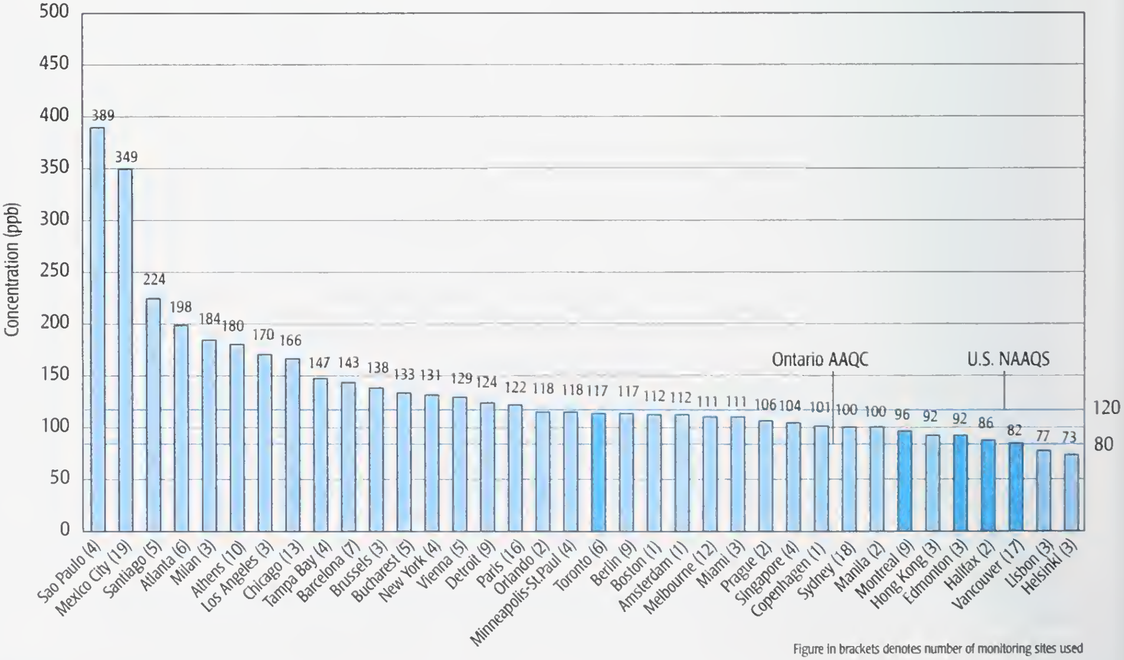
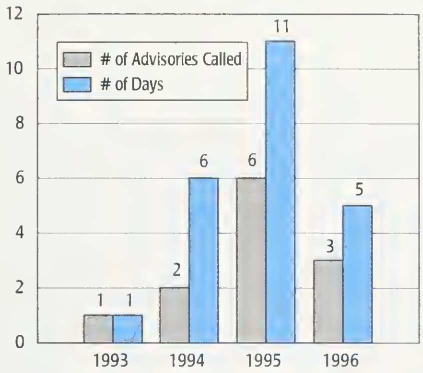


Figure in brackets denotes number of monitoring sites used expected elevated levels. Air quality advisories encourage people to prevent further deterioration of air quality and outline the effects of air pollution on health and the environment. Advisories are made public via the news media, weather offices and weather radio. They are also available at local ministry offices and through the ministry's web site: www.ene.gov.on.ca.

Air quality advisories were issued three times in 1996. One of these lasted for three days (August 5–7) and the other two were for June 28 and August 22. Sixteen advisories were called over the four years 1993 to 1996 (Figure 2.8). In 1993, there was one advisory lasting one day. This was followed by two advisories in 1994 covering a total of six days, six advisories in 1995 covering 11 days, and three advisories in 1996 covering five days. The number and duration of air quality advisories are highly dependent on weather conditions experienced over southern Ontario each summer between May and September.

Figure 2.8

Summary of air quality advisories (1993-1996)

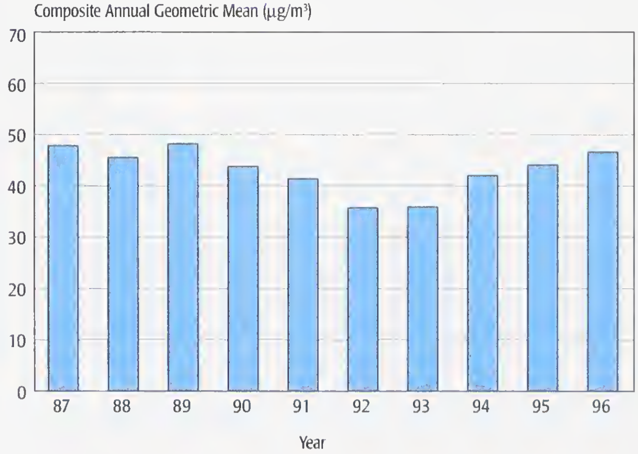


Chapter 3

Particles in Ontario

Particulate matter (PM) is the general term used for a mixture of solid particles and liquid droplets found in the air. These particles, which come in a wide range of sizes, originate from many different stationary and mobile sources as well as from natural sources. They may be emitted directly from a source or formed in the atmosphere by the transformation of gaseous emissions. Composition varies with place, season and meteorology. This chapter discusses the monitoring results and trends for four separate PM monitoring networks, namely total suspended particles (TSP), 24-hour (sampling every sixth day) inhalable particles (PM$_{10}$), suspended particles as measured by the coefficient of haze and, finally, the real-time continuous inhalable (PM$_{10}$) and respirable (PM$_{2.5}$) particles. The 1996 year-in-review for particle monitoring is presented in Appendices 2 and 3.

Figure 3.1
10 year trend for TSP (1987-1996)



Note: 16 sites operated over 10 years

Monitoring for total suspended particles (TSP)

TSP is measured by a hi-vol sampler that draws air through a filter at the rate of 1.4 cubic metres per minute. The 24-hour mass concentration is computed gravimetrically from the mass of the collected particles and the volume of air sampled. Size range varies from 0.1 to 100 µm.

TSP monitoring was conducted at 79 industrial locations in 1996. Since 1989 the ministry has increased monitoring for the smaller fraction (less than 10 microns) of the particles because it is more of a health concern and, because it travels long distances, is linked to trans-boundary pollution.

The lowest TSP levels in the province were measured at Fort Frances where the annual geometric mean was 20.4 µg/m^3. The highest annual mean (90.1 µ/m^3) was recorded in Hamilton downwind of the largest steelmaker in Ontario. Sault Ste. Marie recorded the greatest percentage of samples (32.7) above the 24-hour criterion. This site is close to the Algoma steel plant. The maximum 24-hour reading (455 µg/m^3) was recorded near a sawmill operation in Hearst. Thirty-eight stations (48 per cent) exceeded the 24-hour criterion of 120 µg/m^3 and 18 stations (33 per cent) exceeded the annual criterion of 60 µg/m^3.

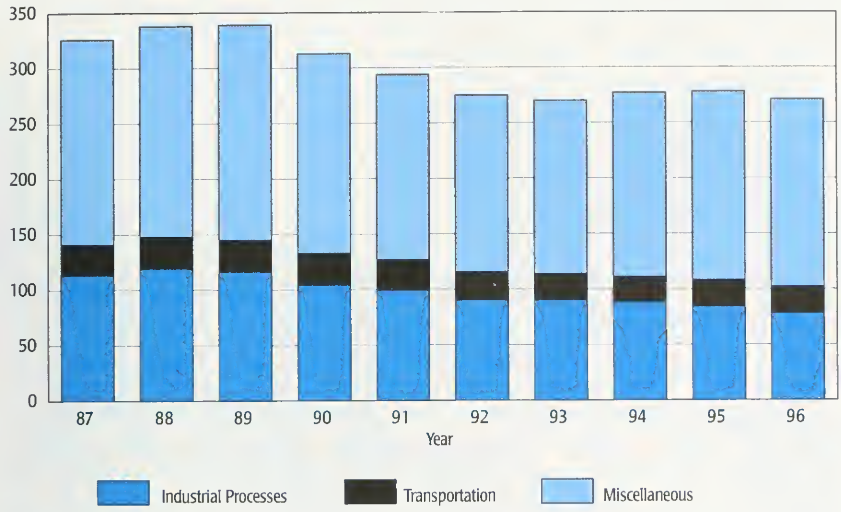
Trends in TSP

The trend in annual mean TSP levels is shown in Figure 3.1. In the early 1990s, total suspended particle levels showed a decrease, primarily due to the economic downturn. However, TSP levels have increased since 1994, reflecting the turnaround in the economy.

Particle emissions from selected major sectors, including transportation and industrial processes, show a slight increase from 1987 to 1989, followed by a decrease from 1990 to 1992 and generally constant over the last four years (Figure 3.2). Fugitive sources such as road dust, construction and surface erosion are not included, nor are emissions from forest fires, which in Northern Ontario can be significant and vary from year to year.

Figure 3.2

Trend for Ontario particle emission estimates (1987-1996)



Monitoring results for lead, trace metals, sulphate and nitrate in TSP

Lead, trace metals, sulphate and nitrate in TSP were measured at 20 to 39 sites depending on the element. Trace metals in TSP considered in this report include chromium (Cr), iron (Fe), manganese (Mn), nickel (Ni), copper (Cu) and vanadium (V). There were two instances of exceeding the lead criterion and six instances of exceeding other selected metal criteria during 1996. Of the two instances of exceeding the 24-hour lead criterion, one was measured near a secondary lead smelter in Toronto and the other near a foundry in Windsor. Five instances of exceeding the criterion due to chromium were recorded in Thorold near a plant that uses magnesium and chromium ores to produce an abrasive product. One instance of exceeding the criterion due to manganese was recorded in Hamilton near the steel works.

Monitoring for 24-hour inhalable particles (PM_{10})

Twenty-four hour inhalable particles (six-day sampling cycle) are measured by a modified hi-vol sampler outfitted with a size selective inlet to restrict particle size to less than 10 µm. As mentioned earlier, this is the size range of the particle most likely to be inhaled and deposited into the deepest part of the lung (thoracic region). The daily mass of the inhalable particle is computed from the mass of the collected particles and the volume of air sampled. Quartz fibre filters are used as the filter medium for collection. Up to 60 per cent of the total particles may consist of the PM_{10} fraction.

In 1996, 24-hour PM_{10} levels were measured at 23 urban locations. Eleven of the 23 sites monitored for ambient levels and the remaining 12 sites monitored a specific source.

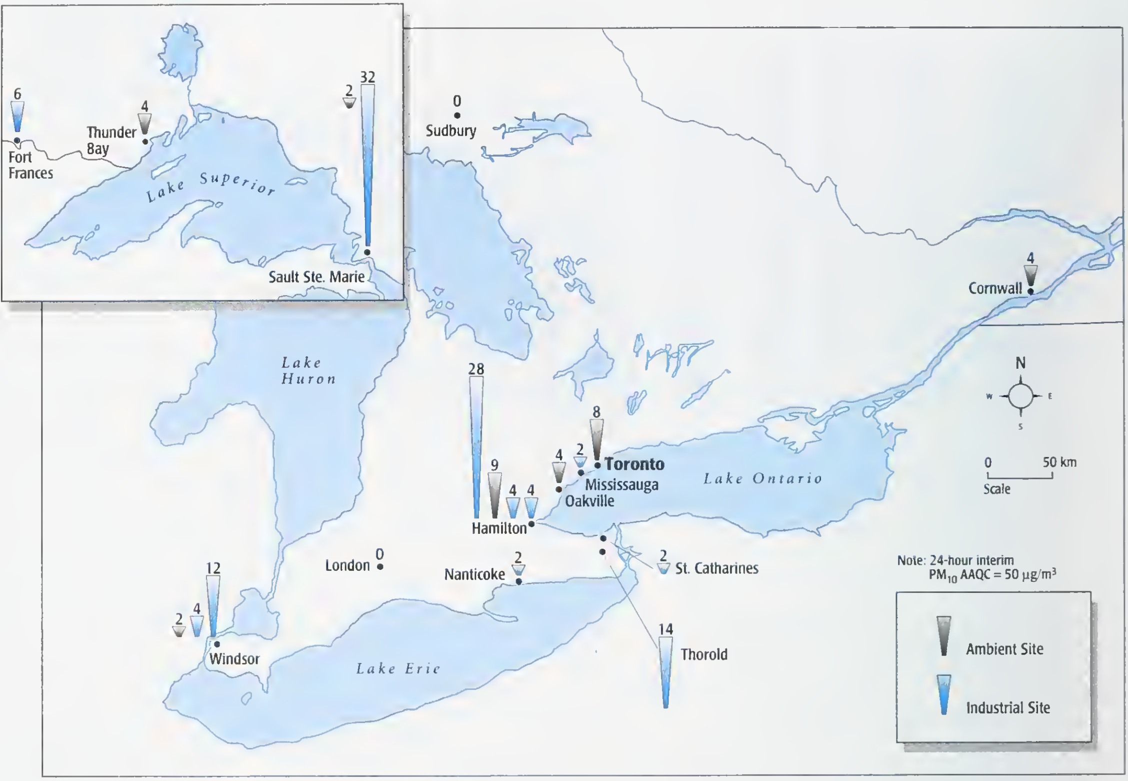
As expected, the highest levels were measured at those sites in the vicinity of industrial sources. The highest annual geometric mean (32.0 µg/m^3) and the maximum 24-hour value (164.0 µg/m^3) were measured in Sault Ste. Marie near the Algoma steel works plant.

For ambient PM_{10} monitoring sites, the highest annual geometric mean (23.9 µg/m^3) was recorded at the Etobicoke site and the maximum 24-hour concentration (91 µg/m^3) at the downtown site in Hamilton.

The percentage of days exceeding the 24-hour interim criterion (50 µg/m^3) for all 23 monitoring

Figure 3.3

Percentage of days exceeding 24-hour interim PM_{10} AAQC (1996)



Note: 24-hour interim PM_{10} AAQC = 50 µg/m^3

sites is shown in Figure 3.3. The percentages vary from a low of 0 per cent at an ambient site in London to 32.0 per cent at an industrial site near the Algoma plant in Sault Ste. Marie. Industrial sites in Sault Ste. Marie, Hamilton, Thorold and Windsor recorded the highest levels of PM_{10} across Ontario during 1996.

Trends in 24-hour PM_{10}

The provincial trend in 24-hour PM_{10} levels for six ambient urban locations over the past six years is shown in Figure 3.4. No trend is apparent; however, the highest composite geometric mean (22.1 µg/m^3) was measured in 1994 and the lowest mean (21.8 µg/m^3) in 1996.

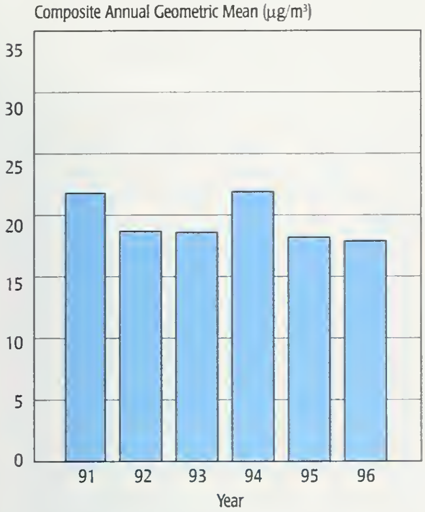
Monitoring results for selected trace metals and sulphate in PM_{10}

Selected trace metals and sulphate in PM_{10} concentrations were measured at 23 locations during 1996. The selected trace metals include copper, iron and manganese. For iron in PM_{10}, the highest mean (2.4 µg/m^3) and the maximum 24-hour concentration (43.0 µg/m^3) were measured near the Algoma steel plant in Sault Ste. Marie. For manganese in PM_{10} the highest mean (0.111 µg/m^3) and the maximum 24-hour value were recorded in Hamilton near the steel works plant. The Inco plant in Sudbury was the source for the highest measured copper annual mean (0.030 µg/m^3) and the maximum 24-hour value (5.0 µg/m^3) during 1996. For sulphate in PM_{10} the highest mean (4.7 µg/m^3) was recorded in Windsor and the maximum 24-hour concentration (38.3 µg/m^3) in Hamilton.

Trends for selected metals and sulphate in PM_{10}

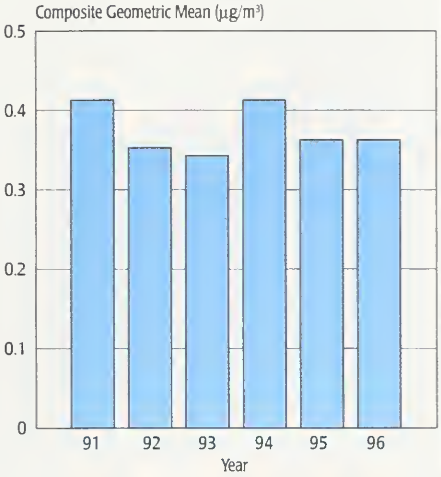
The provincial composite trends in copper, iron, manganese and sulphate in 24-hour PM_{10} for six

Figure 3.4
Trend for 24-hour PM_{10} (1991-1996)



Note: Data for six ambient urban sites

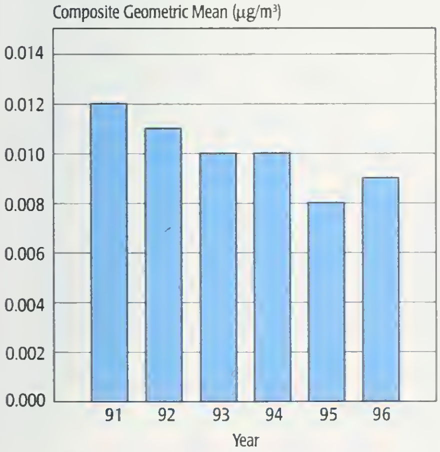
Figure 3.6
Trend for Fe in PM_{10} (1991-1996)



Note: Data for six ambient urban sites

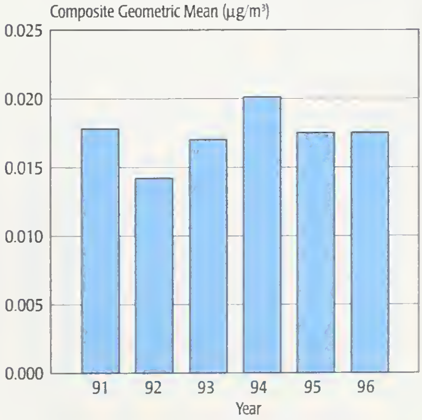
urban locations from 1991 to 1996 are shown in Figures 3.5 to 3.8, respectively. Copper and sulphate show a decreasing trend over the six-year period while iron and manganese are fairly constant over the same period.

Figure 3.5
Trend for Cu in PM_{10} (1991-1996)



Note: Data for six ambient urban sites

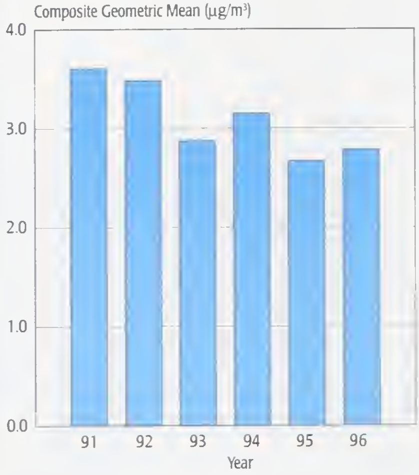
Figure 3.7
Trend for Mn in PM_{10} (1991-1996)



Note: Data for six ambient urban sites

Figure 3.8

Trend for Sulphate in PM_{10} (1991-1996)



Note. Data for six ambient urban sites

International perspective for 24-hour PM_{10}

Toronto ranks eighth best out of 27 world cities when it comes to 24-hour PM_{10} levels during 1995. The worst cities were Santiago and Sao Paulo and the cleanest were Halifax and Vancouver (Figure 3.9).

Monitoring for suspended particles (SP) as measured by co-efficient of haze (COH)

Suspended particles as measured by COH are determined by drawing a known volume of air through a portion of a paper tape. The tape is automatically advanced every hour. The reduction of light transmitted throughout the tape is expressed as co-efficient of haze per 1000 linear feet of air sampled. At the present time suspended particles as measured by the COH monitor are used as real-time estimates of fine particles. They are used in the calculation of the Air Pollution Index and the Air Quality Index.

SP was measured at 34 locations in 1996. The lowest annual mean level (0.14 COH unit) in the province was measured in North Bay. The highest annual mean (0.51 COH unit), highest number of instances (26) of exceeding the 24-hour criterion,

Figure 3.9

Annual mean PM_{10} concentrations in selected world cities (1995)

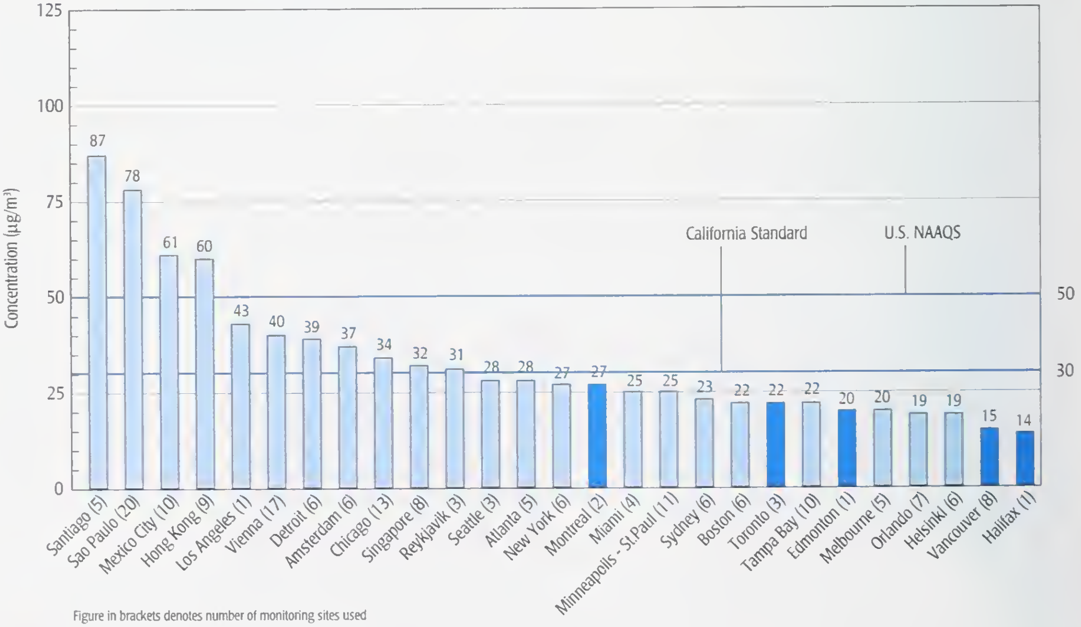


Figure in brackets denotes number of monitoring sites used the maximum one-hour (4.8 COH unit) and 24-hour (1.9 COH unit) values were measured in Hamilton. In 16 stations (49 per cent) the 24-hour criterion was exceeded at least once and in one station in Hamilton the annual criterion was exceeded.

Trends for SP COH

The provincial trend in mean annual SP concentrations for the period 1987 to 1996 is shown in Figure 3.10. From 1987 to 1993 mean annual SP concentrations remained fairly constant. Since 1993 there has been a decreasing trend in provincial SP levels.

Real-time $PM_{10}/PM_{2.5}$ monitoring

In June of 1995, the ministry installed a state-of-the-art continuous (inhalable and respirable) monitoring network of five sites across the province. Continuous hourly measurements of inhalable and respirable particles are obtained by the Tapered Element Oscillating Microbalance (TEOM) method. The TEOM measures the accumulation of mass on a heated filter attached to the tip of a hollow, tapered oscillating glass rod. From change in oscillating frequency, direct measurement of mass accumulation on the filter over time is obtained. The $PM_{10}/PM_{2.5}$ monitoring is intended to allow the capturing of immediate changes in fine particle levels in urban communities, near local industries and in areas affected by trans-boundary sources. 1996 marks the first complete year of monitoring fine particles in real-time. Plans are under way to incorporate real-time PM_{10} into Ontario's Air Quality Index system.

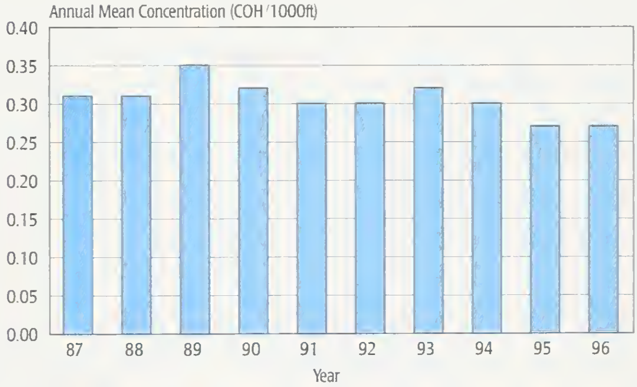
Monitoring results for real-time $PM_{10}/PM_{2.5}$

In 1996, monitoring for real-time PM_{10} was conducted at five urban locations, namely Windsor, London, Hamilton, Kingston and Sault Ste. Marie, and one $PM_{2.5}$ site, Etobicoke. The annual mean levels for PM_{10} ranged from 15.8 µg/m³ in Kingston to 27.1 µg/m³ in Hamilton. The highest 24-hour average (105.8 µg/m³) was recorded in Windsor where trans-boundary impact is significant. The 24-hour interim PM_{10} criterion of 50 µg/m³ was exceeded on 40 days (11 per cent of the year) in Hamilton and on 17 days (5% of the year) in Windsor.

The 1996 annual mean $PM_{2.5}$ level in Etobicoke, based on continuous measurements, was found to be 13.9 µg/m³, with 90 per cent of the data points less than 25.0 µg/m³.

Figure 3.10

10-year trend for SP as measured by COH (1987-1996)



Note: 14 sites operated over 10 years

Chapter 4

Other Principal Contaminants

Pollutants SO_2, NO_2, CO and TRS compounds are discussed in this chapter including their results for 1996, trends and international perspective. A year-in-review for these contaminants is presented in Appendix 1.

SULPHUR DIOXIDE (SO_2)

Monitoring Results for 1996

Monitoring for SO_2 was performed at 52 locations during 1996. Once again, the highest annual mean (10.1 ppb) was measured in Hamilton downwind of the largest steelmaker in Ontario. The highest number of instances (17) when the one-hour AAQC was exceeded was observed in Sudbury. The highest one-hour concentration (724 ppb) was also recorded in Sudbury. Throughout the province a total of 13 SO_2 stations recorded at least one instance of exceeding the one-hour criterion of 250 ppb. Of these 13 stations, 12 are in the Sudbury basin area and one in Wawa.

There were no instances of exceeding the 24-hour criterion of 100 ppb for SO_2 during 1996. Figure 4.1 shows the annual mean SO_2 concentrations across Ontario. Cities with major emission sources, such as

Figure 4.1

Geographical distribution of SO_2 annual mean concentrations (ppb) across Ontario (1996)

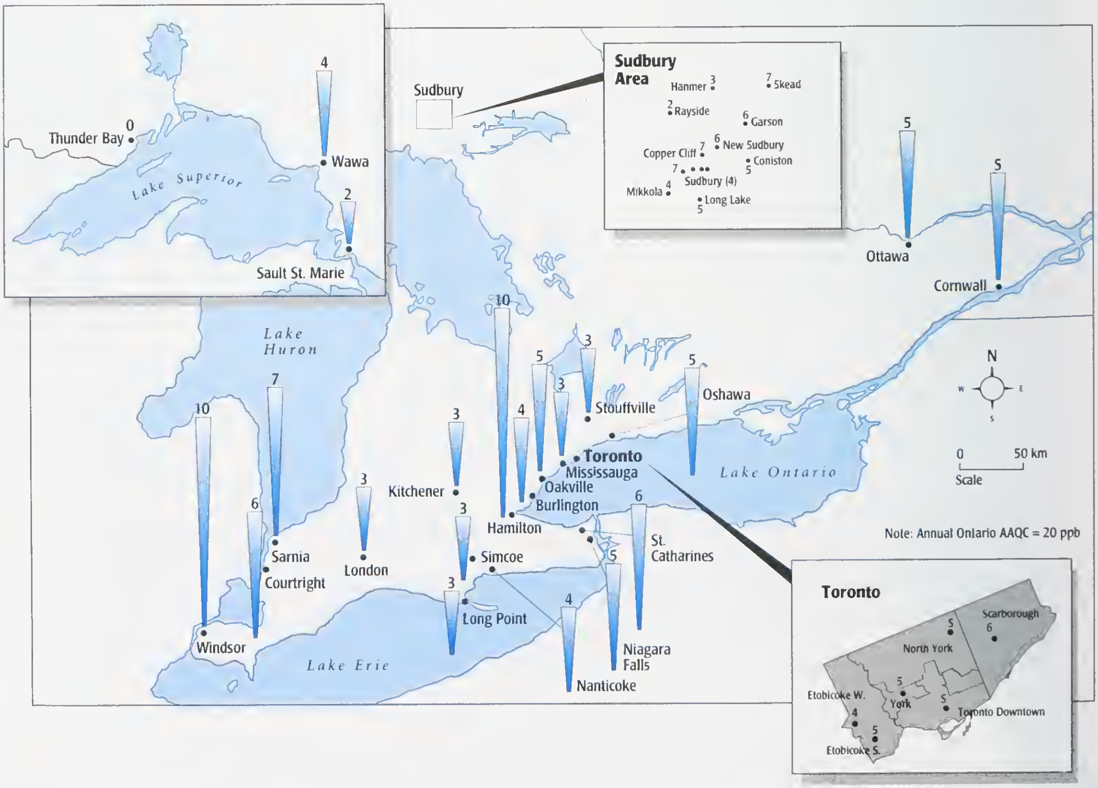
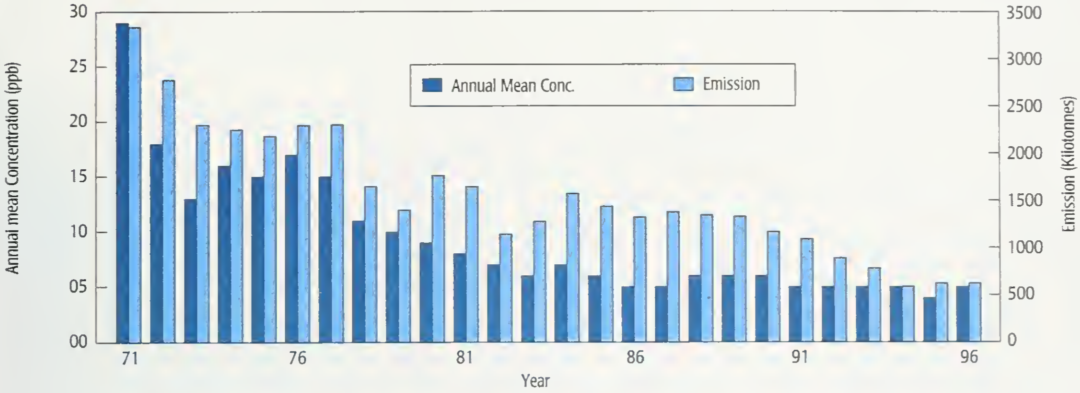


Figure 4.2

Long term air quality and emission trend for sulphur dioxide (1971-1996) in Ontario



Note: 12 sites operated over 26 years Ontario Annual AAQC = 0.020 ppm

Hamilton, Windsor, Sarnia and Sudbury, recorded the highest annual levels in 1996. The annual criterion for SO_2 was not exceeded during 1996.

Trends

Ontario's SO_2 emissions decreased by 81 per cent between 1971 and 1996, while average SO_2 levels in the province improved by 83 per cent during the same period (Figure 4.2). Regulations 346 and 350, control orders on smelting operations and the Countdown Acid Rain program have resulted in significant decreases in emissions. The total Ontario SO_2 emissions in 1996 were 620 kilotonnes. This is well below the 1994 countdown limit of 885 kilotonnes.

International perspective

For sulphur dioxide, Toronto tied for tenth best of 40 cities compared during 1995, Figure 4.3. The worst cities for SO_2 were Mexico City, Prague and Manila and the best were Melbourne, Helsinki and Miami. Toronto's SO_2 levels were similar to those of Vancouver and lower than the levels in both Montreal and Halifax.

Lambton industry meteorological alert (LIMA)

The Lambton industry meteorological alert is covered by the Environmental Protection Act, Regulation 350. Application is limited to that part of the County of Lambton bounded by Lake Huron, the St. Clair River, Highway 80, Moore Township and its continuation through that part of Highway 40, and Lambton County Road 27, which includes Sarnia.

The Minister may declare an alert when the 24-hour running average SO_2 concentration at any station in the LIMA system reaches 70 ppb and meteorological forecasts predict six hours or more of conditions conducive to elevated SO_2 concentrations. The alert is issued at 70 ppb to prevent levels reaching the Ontario 24-hour SO_2 AAQC (100 ppb).

Two monitoring sites are located in Sarnia (Front Street and Centennial Park), one in Corunna (River Bend) and one in Michigan (Port Huron).

The alert was issued four times in 1996, the longest alert being for 30 hours from 9 a.m. February 7 to 2 p.m. February 8. The maximum 24-hour running average of SO_2 (165 ppb) recorded at 10 p.m. on January 22 was the maximum recorded concentration since the inception of the LIMA system in 1982. All four alerts issued during 1996 were based on SO_2 measurements at the Front Street monitor. LIMA alerts called during the past 10 years are shown in Figure 4.4.

NITROGEN DIOXIDE (NO_2)

Monitoring results for 1996

Nitrogen dioxide was monitored at 28 locations in 1996. The highest annual mean concentration (33.9 ppb) was measured in downtown Toronto. The maximum one-hour concentration (171 ppb) and the maximum 24-hour concentration (100.4 ppb) were recorded at the York site in Toronto. Typically,

Figure 4.3

Annual mean SO_2 concentration in selected world cities (1995)

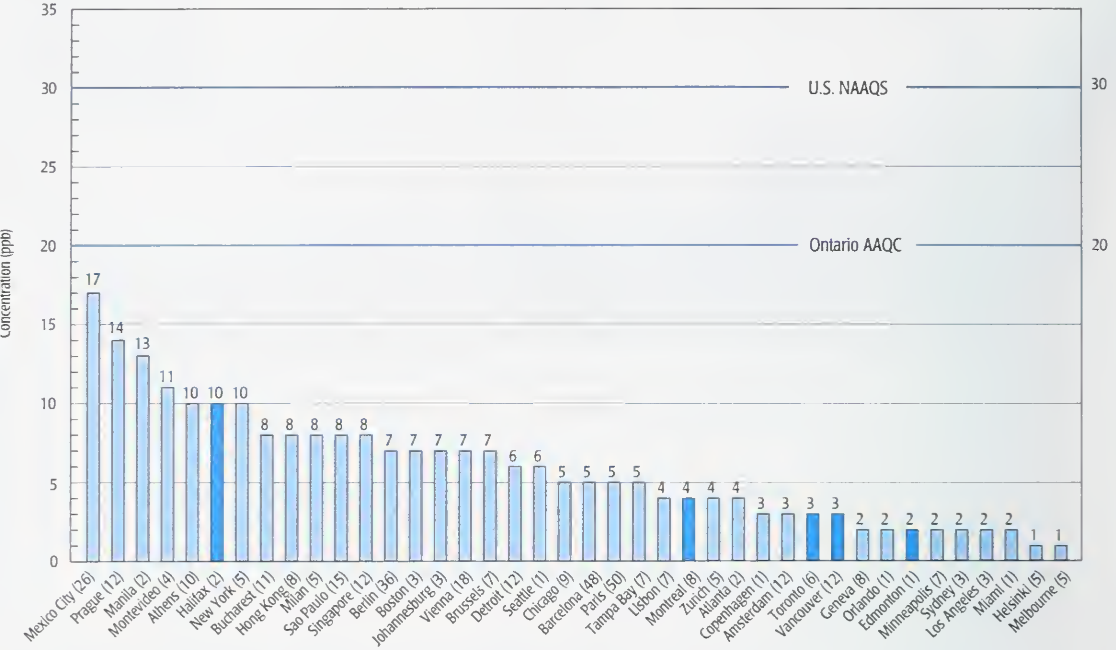


Figure in brackets denotes number of monitoring sites used

Figure 4.4

Lambton Industry Meteorological Alert (LIMA) summary (1987-1996)

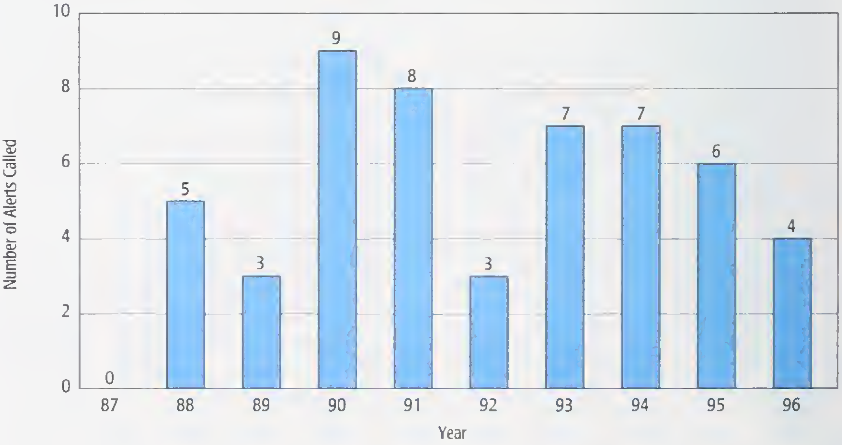
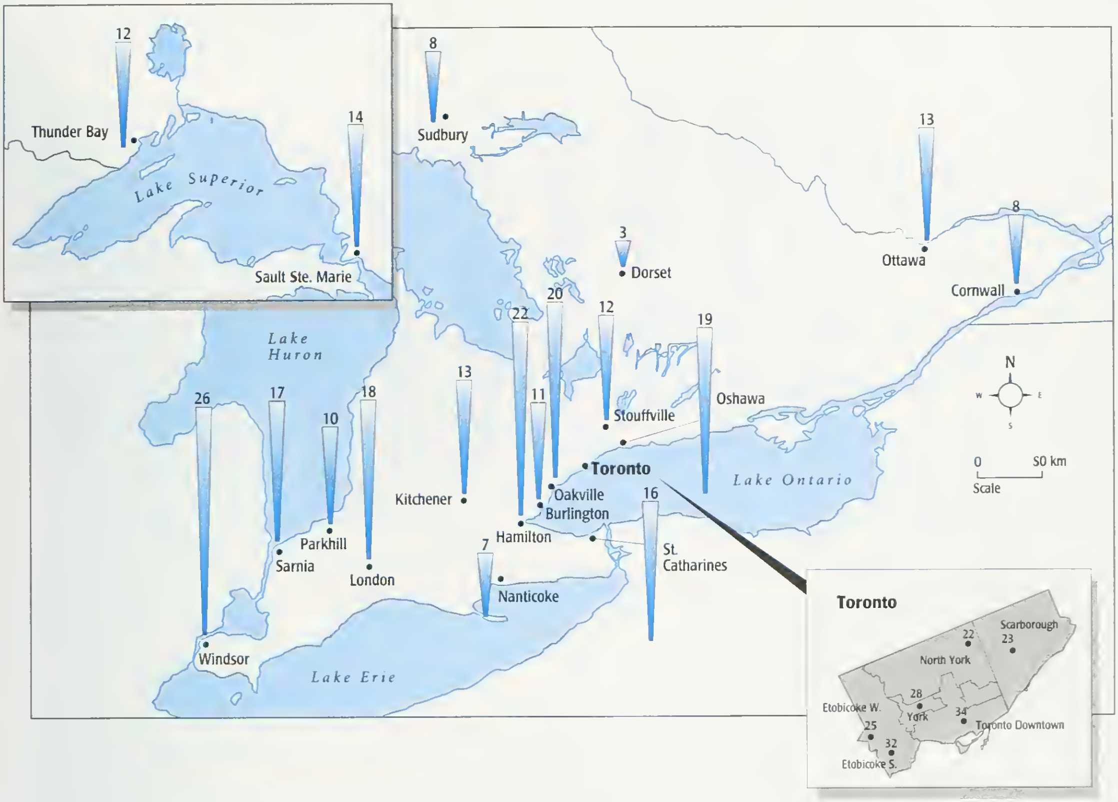


Figure 4.5

Geographical distribution of annual mean NO_2 concentrations (ppb) across Ontario (1996)



highest NO_2 concentrations are recorded in larger urban centres, such Windsor, Hamilton and Toronto (Figure 4.5). The one-hour criterion of 200 ppb for NO_2 was not exceeded during 1996. However, there was one instance of exceeding the 24-hour limit of 100 ppb. This occurred at the York site in Toronto.

Trends

Provincial average ambient NO_2 levels have remained relatively constant throughout the 1990s. Average concentrations in 1996 were five per cent lower than the levels recorded in 1987 (Figure 4.6). Provincial NOx emissions have decreased 26 per cent since 1989 (Figure 4.7). The decreasing trend is largely due to reductions in emissions in the industrial and transportation sectors.

International perspective

Of 41 world cities, Toronto's air quality ties for 18th best when it comes to nitrogen dioxide levels in 1995 (Figure 4.8). The worst cities were Montevideo, Manila and Los Angeles and the best were Helsinki and Havana. Elevated NO_2 levels in the major cities are attributed primarily to motor vehicle emissions.

CARBON MONOXIDE (CO)

Monitoring results for 1996

Carbon monoxide was monitored at 20 locations in 1996. The highest annual mean (1.3 ppm) was recorded at the downtown Toronto site while the highest one-hour measured value (23 ppm) and the highest eight-hour measured value (11 ppm) occurred at the downtown Hamilton site. Highest CO

Figure 4.6

10 year trend for NO_2 levels (1987-1996)

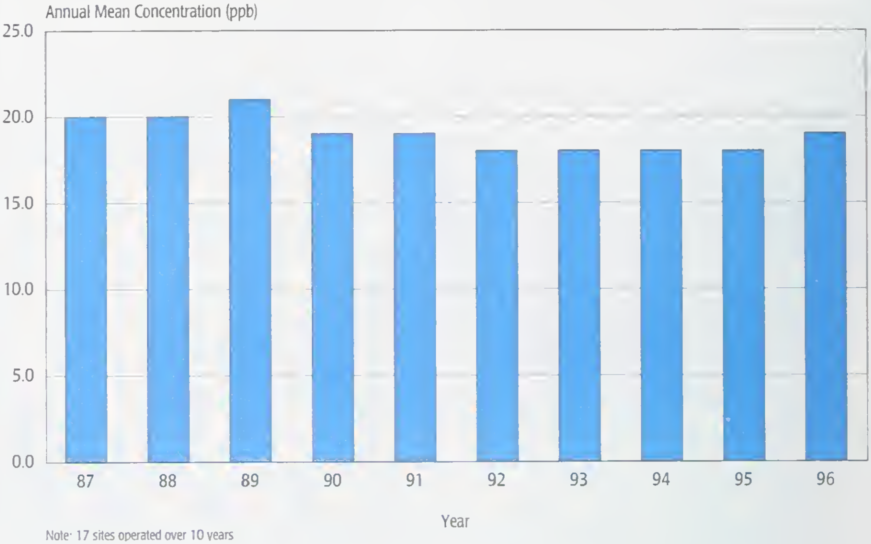


Figure 4.7

Trend for Ontario nitrogen oxides emission estimates (1987-1996)

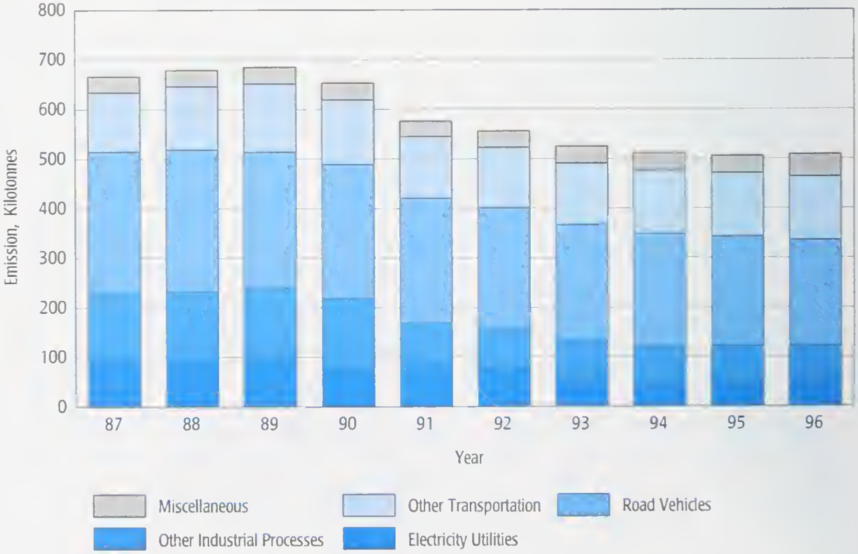


Figure 4.8

Annual mean nitrogen dioxide levels in selected world cities (1995)

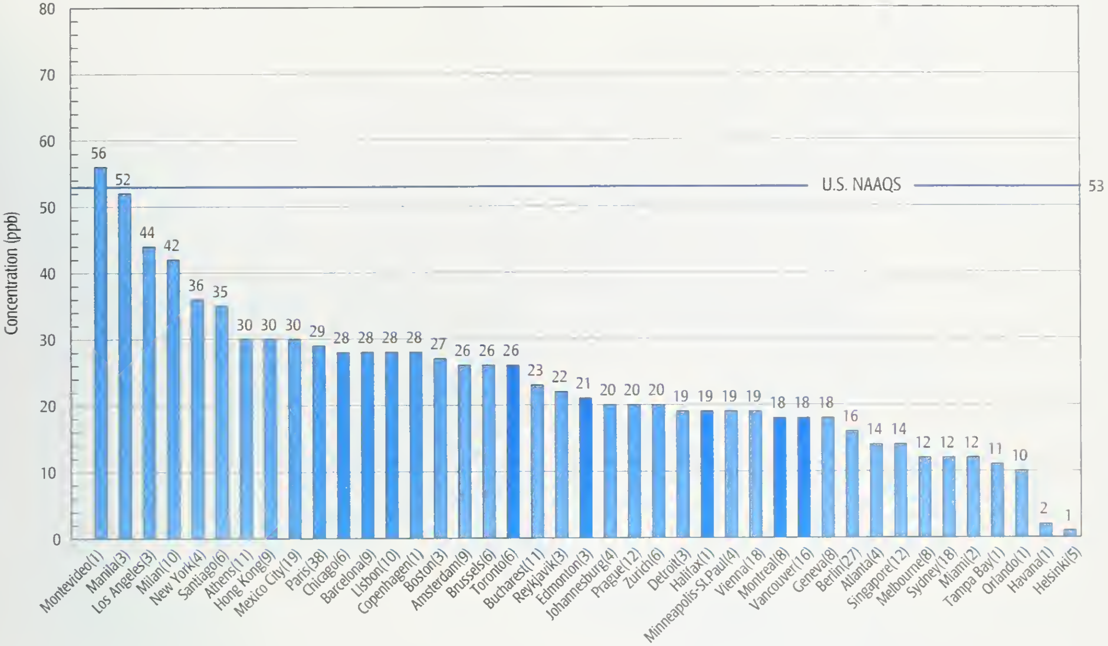


Figure in brackets denotes number of monitoring sites used

levels are recorded typically in larger urban centres as a result of vehicle emissions (Figure 4.9). There were no instances of exceeding the one-hour or eight-hour AAQC in 1996. The CO one-hour and eight-hour AAQC have not been exceeded since 1991.

Trends

The trend in provincial averaged one-hour and eight-hour maximum CO concentrations are shown in Figure 4.10 for the period 1987 to 1996. Over this 10-year period, ambient CO concentrations as measured by the composite average of the one- and eight-hour maximums were reduced by 27 and 28 per cent, respectively. These reductions in ambient CO levels occurred despite a 22 per cent increase in vehicle-kilometres travelled over the same 10-year period (Figure 4.11).

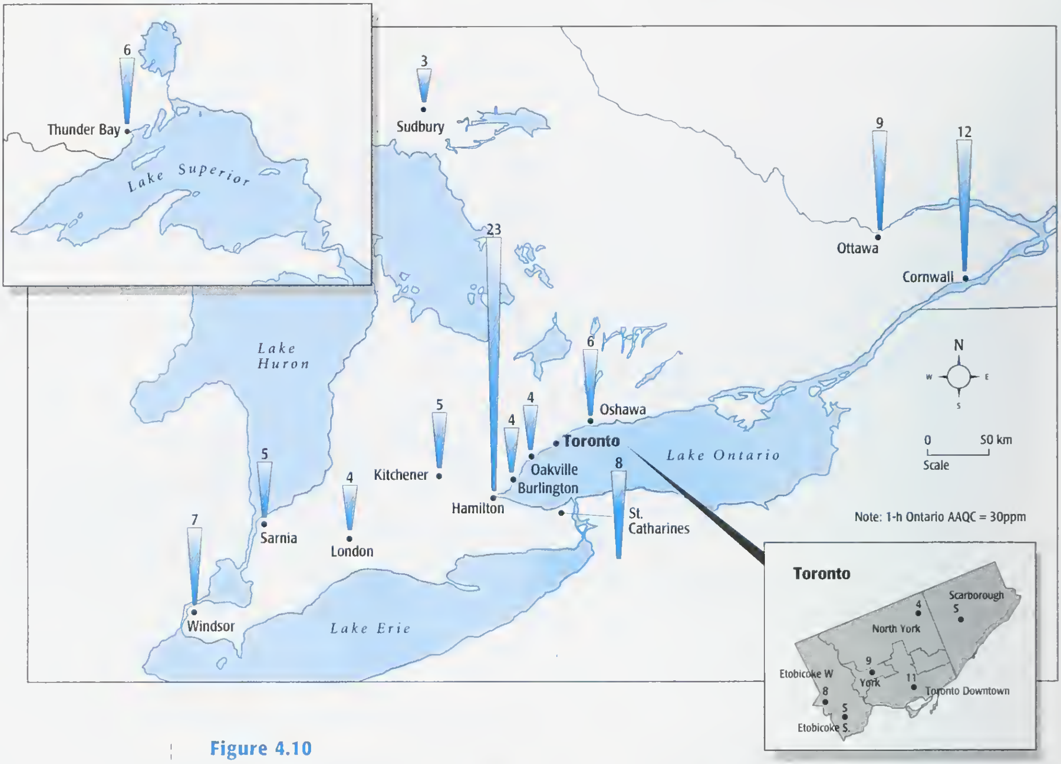
Provincial CO emissions show a decline since 1989 due to the new vehicle emission standards (Figure 4.12). The transportation sector accounts for 65 per cent of the provincial total CO emissions. Since 1987, emissions from this sector have decreased by about 17 per cent.

International perspective

Toronto ranks tenth best out of 38 world cities for one-hour maximum carbon monoxide concentrations during 1995 (Figure 4.13). Toronto CO levels were lower than those of other Canadian cities, such as Vancouver, Montreal and Edmonton. Overall, the highest levels of CO were recorded in Mexico City, Santiago and Sao Paulo, all three exceeding both the Ontario and USEPA standards for one-hour CO during 1995.

Figure 4.9

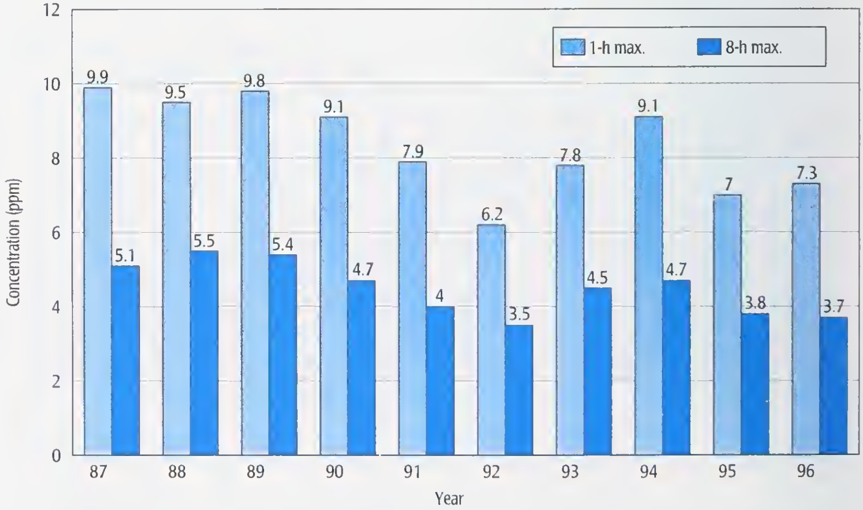
Geographical distribution of one-hour maximum CO concentrations (ppm) across Ontario (1996)



Note: 1-h Ontario AAQC = 30ppm

Figure 4.10

10 year trend for CO 1-hour and 8-hour maximums (1987-1996)



Note: 1-h AAQC = 30ppm; 8-h AAQC = 13ppm

Figure 4.11

Ontario vehicle-kilometres travelled (1987-1996)

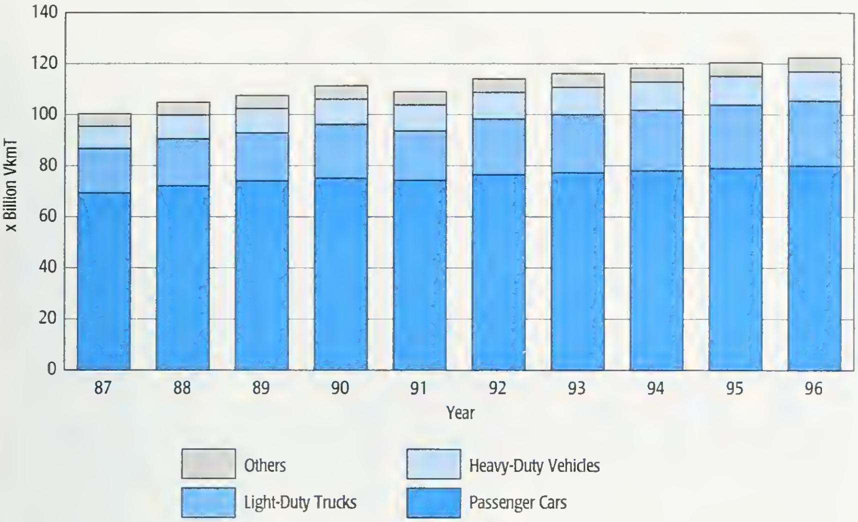


Figure 4.12

Trend for Ontario carbon monoxide emission estimates (1987-1996)

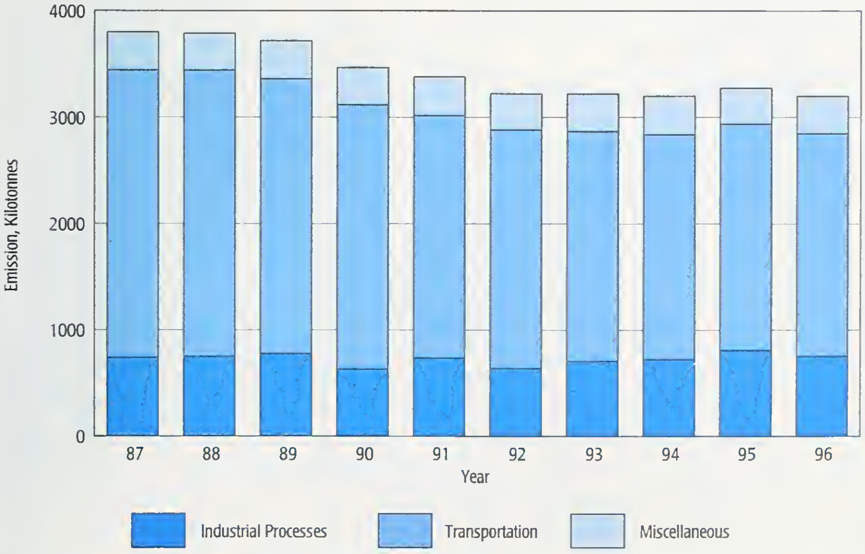


Figure 4.13

Maximum 1-hour CO concentrations in selected world cities (1995)

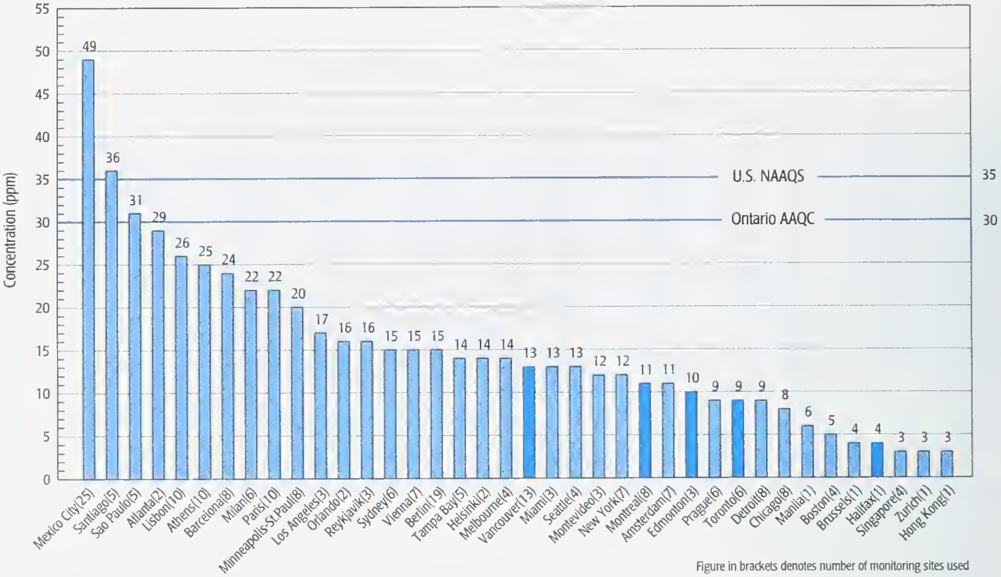
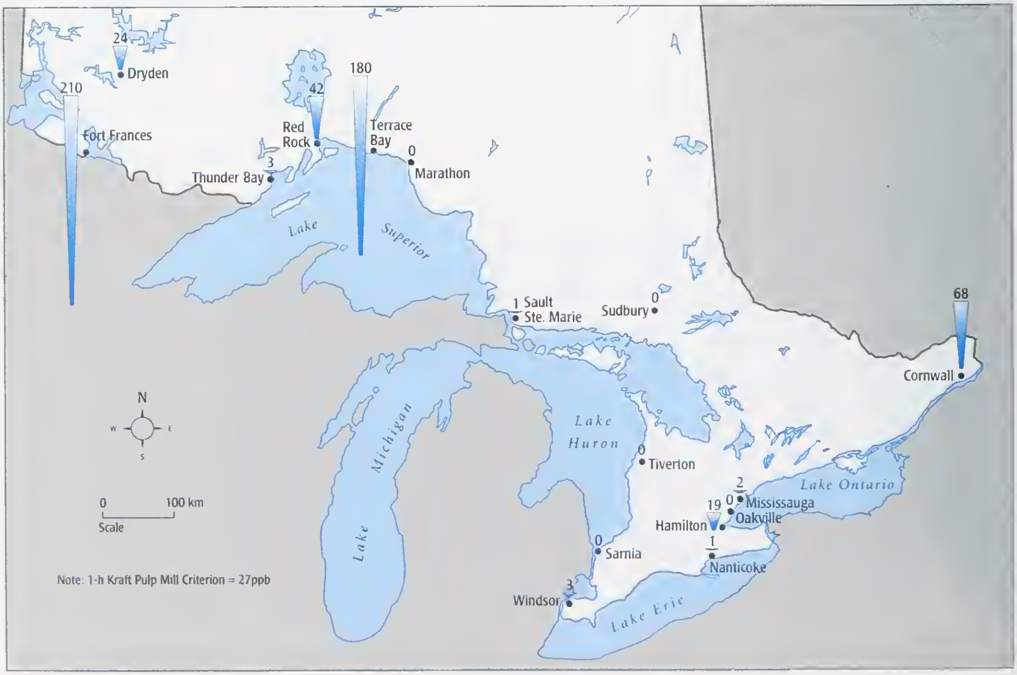


Figure in brackets denotes number of monitoring sites used

Figure 4.14

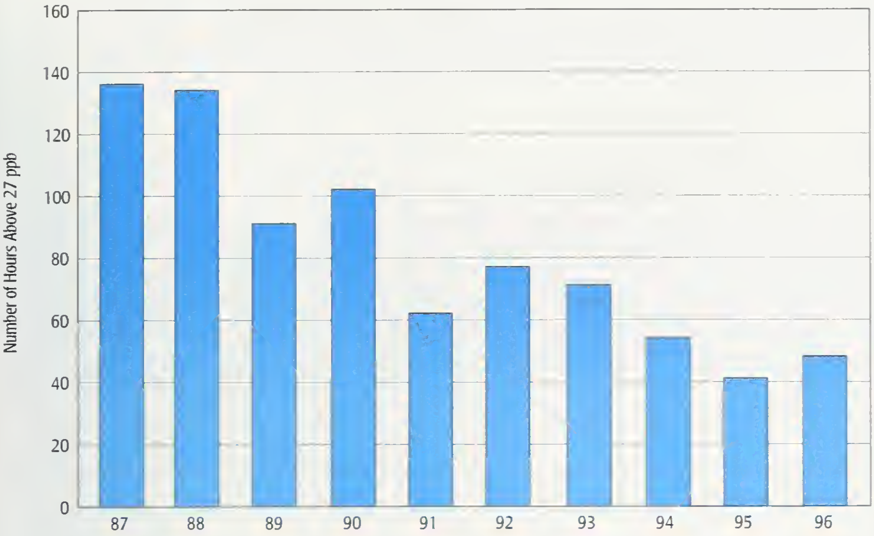
Geographical distribution of TRS 1-hour exceedances of the Kraft Pulp Mill AAQC across Ontario (1996)



Note: 1-h Kraft Pulp Mill Criterion = 27ppb

Figure 4.15

10 year trend of 1-hour TRS concentrations > 27 ppb at sites in the vicinity of Kraft Pulp Mills (1987-1996)



Note: 7 sites operated over 10 years; TRS Kraft Pulp Mill AAQC is 27 ppb

TOTAL REDUCED SULPHUR (TRS) COMPOUNDS

Monitoring results for 1996

Monitoring for TRS was carried out at 34 locations. The highest annual mean concentration (3.0 ppb) was recorded at the Cornwall location. The highest one-hour concentration (276.0 ppb) and the greatest number of instances (210) when the one-hour kraft pulp mill criterion was exceeded were recorded in Fort Frances. Twenty-two out of 34 monitoring locations recorded instances above the TRS criterion during 1996. Figure 4.14 shows the spatial distribution across Ontario of the number of instances when the kraft pulp mill criterion was exceeded. As expected the highest numbers for exceeding the criterion were in communities with kraft pulp mills and/or steel mills.

Trends

The trend in provincial composite averaged TRS levels above the 27 ppb criterion in the vicinity of kraft pulp mills is shown in Figure 4.15. Over the 10-year period, the composite number of instances above the TRS one-hour kraft pulp mill criterion has decreased 64 per cent. This decrease is mainly attributed to abatement and regulatory action taken by the ministry over the years.

Chapter 5

Air Quality Indices

Air Quality Index (AQI)

The Ministry of the Environment operates an extensive network of air quality monitoring sites across the province. In 1996, the AQI network consisted of 29 sites in 24 urban centers. Figure 5.1 shows the location of the AQI sites.

This network, in place since 1988, provides the public with real-time air quality information across the province. The AQI is based on pollutants that have adverse effects on human health and the environment: sulphur dioxide (SO_2), ozone (O_3), nitrogen dioxide (NO_2), total reduced sulphur (TRS) compounds, carbon monoxide (CO) and suspended particles (SP). At the end of each hour the concentration of each pollutant measured at a particular site is converted into a number that ranges from 0 upwards. The calculated number for each pollutant is called a sub-index.

The highest sub-index at the given hour becomes the AQI. The index increases as the air quality deteriorates. The index values, corresponding categories and potential health and environmental effects are shown in Table 5.1.

If the AQI value is in the range from 32 to 49 there may be some adverse health effects on very sensitive people. An index value in the range 50 to 99 may have adverse effects on the most sensitive of the human or animal population or may cause significant damage

Figure 5.1

Geographical distribution of the number of hours AQI >31 across Ontario (1996)

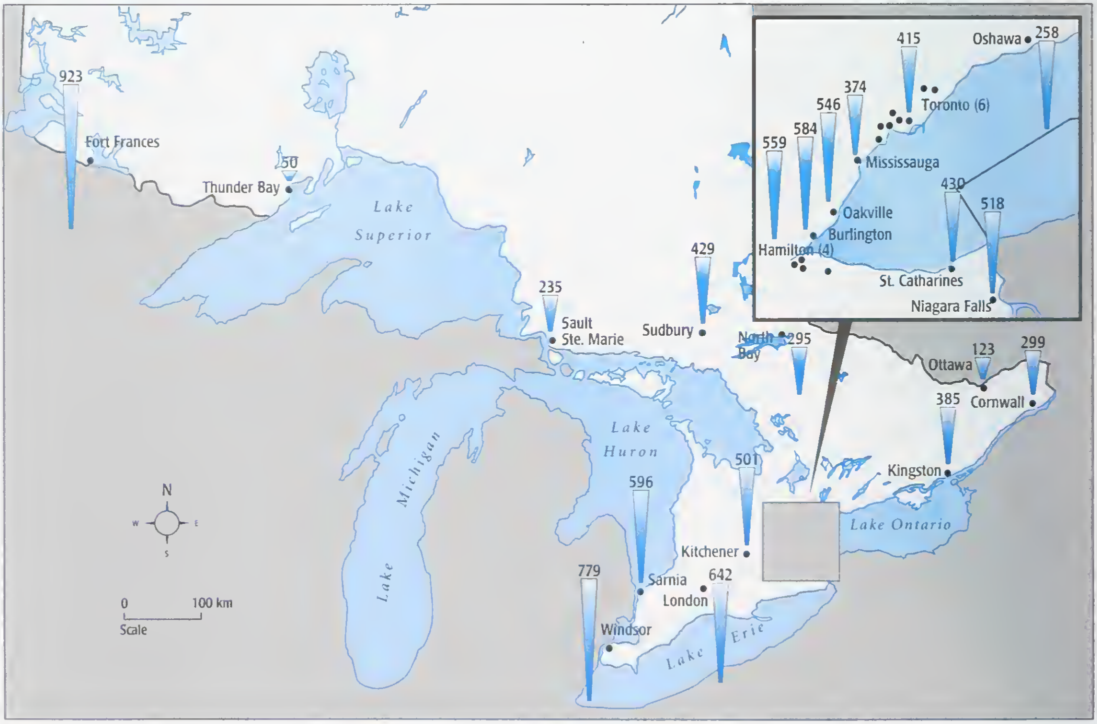


Table 5.1
Air quality index pollutants and their impact.

Index	Category	Carbon Monoxide (CO)	Nitrogen Dioxide (NO_2)	Ozone (O_3)	Sulphur Dioxide (SO_2)	Suspended Particles (SP)	SO_2 + SP (As Measured by the API)	Total Reduced Sulphur (TRS)
0-15	Very good	No known harmful effects	No known harmful effects	No known harmful effects	No known harmful effects	No known harmful effects	No known harmful effects	No known harmful effects
16-31	Good	No known harmful effects	Slight odor	No known harmful effects	Damages some vegetation in combination with ozone	No known harmful effects	No known harmful effects	Slight odor
32-49	Moderate	Blood chemistry changes , but no noticeable impairment	Odor	Respiratory irritation in sensitive people during vigorous exercise; people with heart/lung disorders at some risk; damages very sensitive plants	Damages some vegetation	Some decrease in visibility	Damages vegetation (i.e. tomatoes, white beans due to sulphur dioxide)	Odor
50-99	Poor	Increased symptoms in smokers with heart disease	Air smells and looks brown. Some increase in bronchial reactivity in people with asthma	Sensitive people may experience irritation when breathing and possible lung damage when physically active; people with heart/lung disorders at greater risk; damage to some plants	Odorous; increasing vegetation damage	Decreased visibility; soiling evident	Increased symptoms for people with chronic lung disease	Strong odor
100 or over	Very poor	Increasing symptoms in non-smokers with heart diseases; blurred vision; some clumsiness	Increasing sensitivity for people with asthma and bronchitis	Serious respiratory effects, even during light physical activity; people with heart/lung disorders at high risk; more vegetation damage	Increasing sensitivity for people with asthma and bronchitis	Severe odor; some people may experience nausea and headaches	Significant effects for people with asthma and bronchitis	Severe odor; some people may experience nausea and headaches

to vegetation and property. An AQI value of 100 or more may cause adverse effects to the health of a large sector of those exposed.

The Air Pollution Index (API) is also a sub-index of the AQI. The basis of an alert and control system to warn of deteriorating air quality, the API is derived from 24-hour running averages of SO_2 and SP.

Regulation 346 under the Environmental Protection Act (1971) authorizes the Minister of the Environment to order any source not essential to public health or safety to curtail or cease operations when the API exceeds 50 and ministry meteorologists forecast at least six hours of adverse atmospheric conditions.

The Air Quality Office at the Environmental Monitoring and Reporting Branch continually obtains data from the 29 AQI sites .

Computed air quality indices and AQI forecasts are released to the public and news media at set intervals. The public can access the index values by calling the ministry's automatic telephone answering device (English recording - local calls 416-246-0411 or 1-800-387-7768; French recording - 1-800-221-8852). The AQI can also be obtained from the ministry's Web site: www.ene.gov.on.ca.

AQI forecasts based on the meteorological conditions and pollutant trends are provided daily.

Summary Air Quality Index levels (1996)

The frequency distribution of hourly AQI, according to descriptive category and to pollutant responsible for AQI above 31, is shown for the 29 monitoring locations in Table 5.2 . The data are presented for the AQI stations grouped by regions. Air quality was most often in the "good/very good" categories at all air quality sites across the province. Based on the cumulative total number of monitored hours (247,550) at the 29 sites, on average, good to very good air quality was reported 95.3 per cent of the time. Good to very good air quality readings ranged from 89.5 per cent at Fort Frances to 99.4 per cent at Toronto Downtown.

The geographical distribution of the number of hours of AQI > 31 is shown in Figure 5.1. The large number of hours at sites in southwest Ontario is due primarily to high levels of ozone, whereas the higher number of hours in Fort Frances is due to TRS compounds. There were 11,808 hours (4.8 per cent of hours monitored) of moderate to poor air quality recorded at the 29 sites in 1996. Except at Fort Frances, ozone was the most frequent cause of index readings over 31. Total reduced sulphur compounds were the most frequent cause of high indices in Fort Frances.

Hamilton Downtown recorded six hours of moderate air quality due to the eight-hour running average of CO. This was the only AQI site that recorded air quality index values due to the eight-hour running average of CO.

There were only two hours of moderate or poor air quality due to SO_2 reported at all of the AQI sites during 1996, both reported in Sudbury. No hours of very poor air quality were recorded at the AQI sites during 1996.

In Table 5.2 the number of days during which the AQI at each site was greater than 31 for at least one hour is also shown. The number of days varied from 16 at Thunder Bay to 175 at Fort Frances. The graphs in Figures 5.2a to 5.2e present the AQI and

Table 5.2

Air quality index summary (1996)

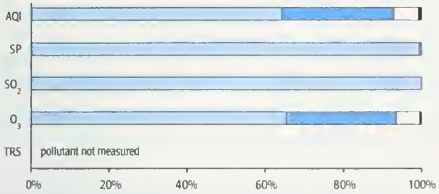
		Number of Hours AQI in Range					# of hrs Pollutant Responsible For AQI >31							# of days at least 1hr >31
Stn ID	City	Very Good 0	Good 16-31	Mod. 32-49	Poor 50-99	Very Poor 100+	SP	O_3	TRS	SO_2	API	CO	NO_2	
12008	Windsor U	5694	2495	524	71	0	3	592	x	0	0	0	0	87
12016	Windsor	5297	2660	664	115	0	17	711	51	0	0	x	x	122
14064	Sarnia	4407	3781	547	49	0	4	588	4	0	0	0	0	92
15025	London	5298	2837	571	71	0	0	642	x	0	0	0	0	90
26060	Kitchener	4653	3621	486	15	0	0	501	x	0	0	0	0	76
27067	St Catharines	5364	2903	411	19	0	2	428	x	0	0	0	0	72
27072	Niagara Falls **	2564	2929	495	23	0	0	518	x	0	0	x	x	80
29000	Hamilton Dt	4865	3495	418	5	0	44	322	48	0	3	6	0	81
29105	Hamilton E **	3209	2470	247	7	0	9	244	1	0	0	x	x	50
29114	Hamilton Mt	5032	3193	545	14	0	5	530	24	0	0	x	0	80
29118	Hamilton W	5286	3115	374	9	0	6	345	32	0	0	x	0	72
31303	Toronto Dt	6729	2000	53	0	0	20	33	x	0	0	0	0	24
33003	Scarborough	5673	2707	317	21	0	3	335	x	0	0	0	0	62
34020	North York	5636	2958	182	6	0	16	172	x	0	0	0	0	47
35003	Etobicoke	5787	2711	256	1	0	10	247	x	0	0	0	0	57
35033	Etobicoke	6114	2293	367	9	0	30	346	x	0	0	0	0	72
36030	York	5384	2815	367	48	0	33	382	x	0	0	0	0	82
44008	Burlington	4620	3580	533	51	0	22	562	x	0	0	0	0	96
44015	Oakville	5092	2979	508	38	0	4	542	0	0	0	0	0	88
45025	Oshawa	4878	3640	249	9	0	0	258	x	0	0	0	0	56
46110	Mississauga	5426	2667	358	16	0	13	361	x	0	0	0	0	79
51001	Ottawa	5322	2989	120	3	0	4	119	x	0	0	0	0	29
52020	Kingston	4864	3375	377	8	0	3	382	x	x	x	x	x	62
56051	Cornwall	5420	3054	291	8	0	2	261	36	0	0	x	0	78
62030	Fort Frances	3080	4775	707	216	0	28	178	717	x	x	x	x	175
63200	Thunder Bay	4791	3943	50	0	0	3	42	5	0	0	0	0	16
71068	Sault Ste. Marie	4484	4065	220	15	0	15	189	31	0	0	x	0	58
75010	North Bay	3947	4438	276	19	0	0	295	x	x	x	x	x	48
77203	Sudbury	3368	4970	423	6	0	2	425	0	2	0	0	0	69

** - Site terminated in Sep. 96 x - pollutant not measured

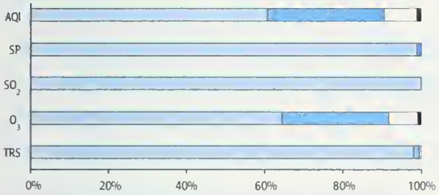
Figures 5.2a and 5.2b

AQI and sub-index summary statistics for each AQI site by region

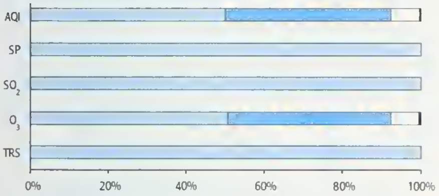
Windsor - 12008



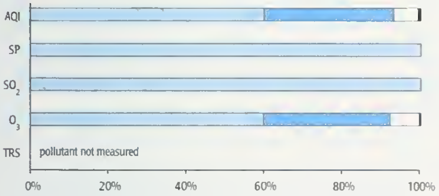
Windsor - 12016



Sarnia - 14064



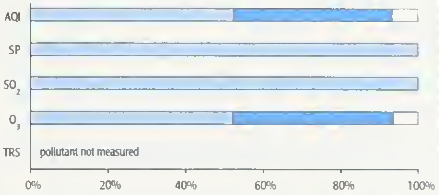
London - 15025



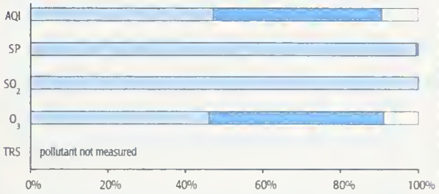
▨ Very Good ▨ Good ☐ Moderate ■ Poor

Note: NO_2 and CO were in the Very Good category 100% of the time.

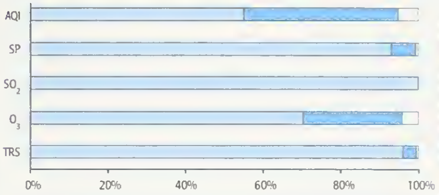
Kitchener - 26060



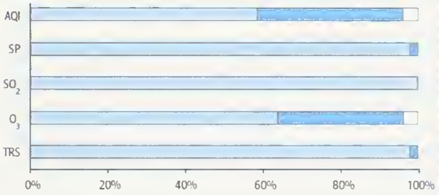
Niagara Falls - 27072



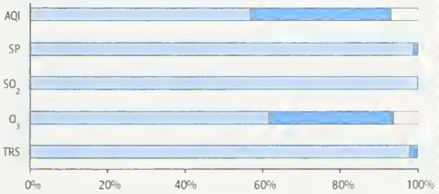
Hamilton Downtown - 29000



Hamilton East - 29105



Hamilton Mountain - 29114



Hamilton West - 29118

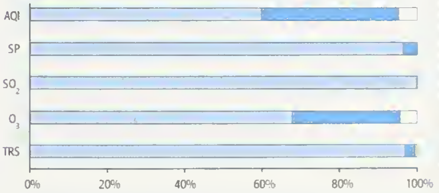
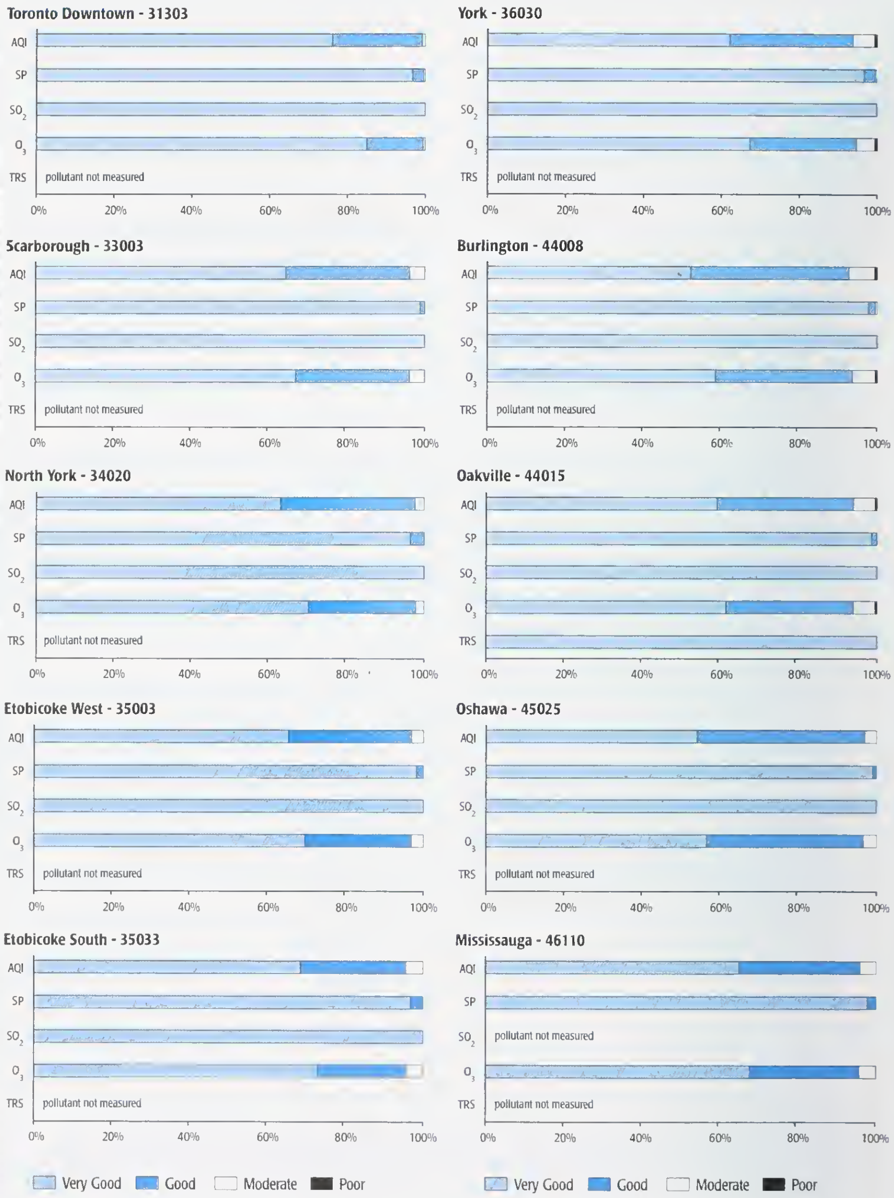


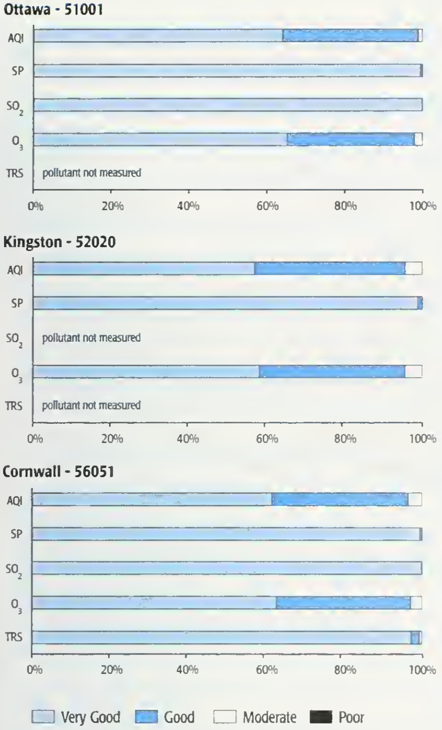
Figure 5.2c



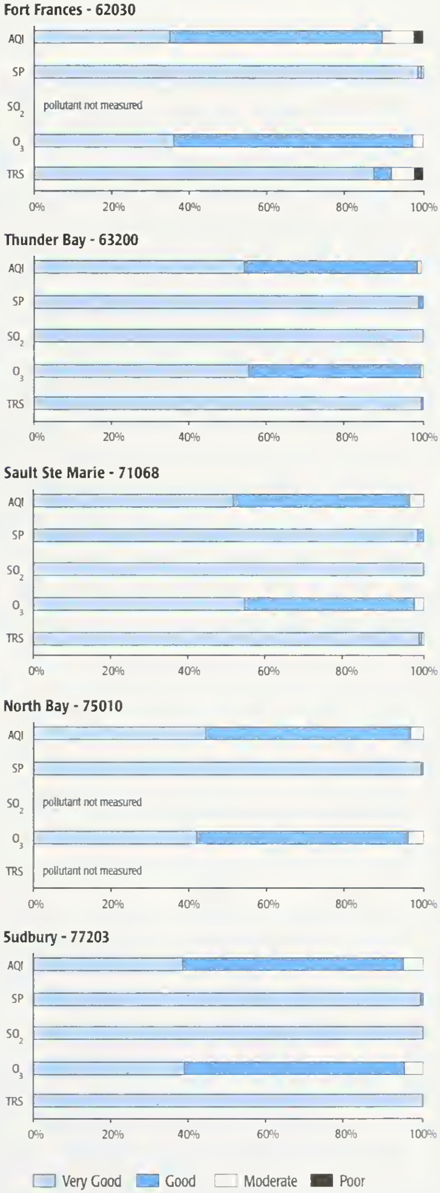
Note: NO_2 and CO were in the Very Good category 100% of the time.

Note: NO_2 and CO were in the Very Good category 100% of the time.

Figures 5.2d and 5.2e



Note: NO_2 and CO were in the Very Good category 100% of the time.



Note: NO_2 and CO were in the Very Good category 100% of the time.

sub-index summary statistics for each AQI site by region. The bar graphs show the percentage of time the Air Quality Index was in each category and the percentage time each sub-index was in a particular category for the entire year.

Summary statistics for each region are presented in Table 5.3, showing the percentage time that the AQI was in each category and also the percentage time each pollutant caused the AQI to be greater than 31. The table shows that in 1996 the southwest region had the highest percentage time with moderate and poor air quality. However, the northern region had the least percentage of very good air quality. More than 50 per cent of the AQI was in the good range. This is due to the higher number of ozone values in the good category during the winter and spring seasons in Northern Ontario.

Regional AQI trends (1992-1996)

A five-year trend (1992-1996) for the number of hours that the AQI was greater than 31 by regions is

Table 5.3

AQI summary statistics by regions –1996

Regions	% Time AQI in Range				% Time Pollutant Responsible for AQI > 31						
	Very Good	Good	Mod.	Poor	SP	O_3	TRS	SO_2	API	CO	NO_2
Southwest	58.9	33.6	6.6	0.9	1.0	97.0	2.0	0.0	0.0	0.0	0.0
West Central	55.6	38.9	5.3	0.2	2.2	94.1	3.4	0.0	0.1	0.2	0.0
GTA	63.6	32.5	3.7	0.2	4.5	95.5	0.0	0.0	0.0	0.0	0.0
Eastern	60.4	36.4	3.0	0.1	1.1	94.4	4.5	0.0	0.0	0.0	0.0
Northern	44.9	50.7	3.8	0.6	2.5	58.4	39.0	0.0	0.0	0.0	0.0

shown in Figure 5.3. The average number of AQI hours greater than 31 at sites in the southwest region showed a continuous increase during this period. This is due to the increase in the number of hours that the AQI due to ozone exceeded 31. The southwest region is very close to the U.S. sources of emissions that produce ozone, and the air quality is affected by ozone and its precursors transported into the area. The west central region and the Greater Toronto Area showed a slightly increasing trend. In these regions although the number of AQI hours greater than 31 due to SP are more than the number in other regions, ozone is still the pollutant that most often exceeds the threshold of 31. However, due to the emissions (from the large number of vehicles, especially in the GTA) reacting with ozone, there is a smaller number of AQI hours greater than 31 due to ozone. The eastern and northern regions showed a slight decrease in the average number of hours exceeding 31. In northern Ontario there has been a reduction of TRS levels at Fort Frances.

Air Pollution Index (API)

During 1996, Hamilton Downtown was the only site in the province that reached an API at 32, for three hours from 5 p.m. to 7 p.m. inclusive on June 19, 1996. No alert was issued because adverse meteorological conditions were not forecast to last for six hours.

Figure 5.3

Trend of the average number of hours AQI >31 for various regions of Ontario (1992-1996)

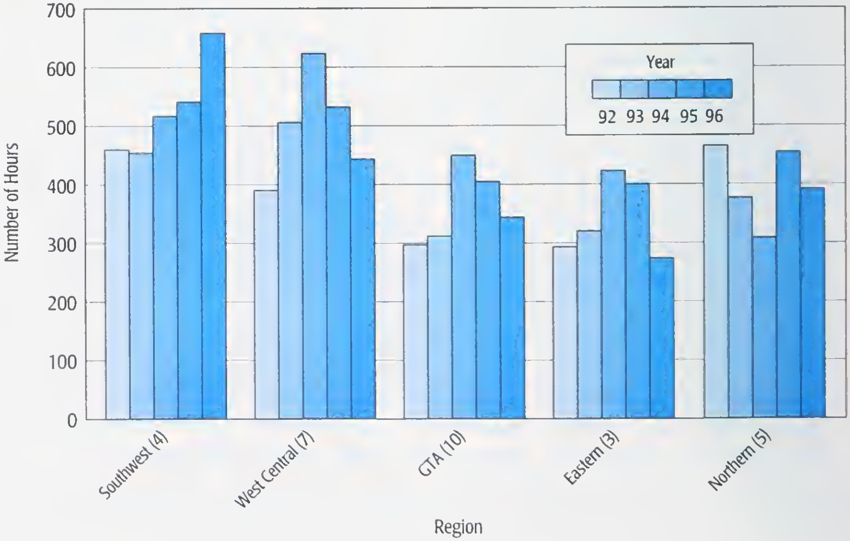


Figure in brackets denote number of monitoring sites

Chapter 6

Special Purpose Monitoring

A number of special purpose monitoring activities are carried out by the Ministry of the Environment. These include:

- Volatile organic compound (VOC) network. Some VOCs are of concern because they are toxic and/or are important because they are part of the formation of smog.
- Persistent organic pollutants (POPs) as monitored in the Great Lakes toxics network. These compounds include a number of pesticides. Many are known to be toxic, and they are capable of being transported very long distances in the atmosphere.
- Dioxin and furan monitoring.

Monitoring sites for these three networks are shown in Figure 6.1. Results from the networks are presented below.

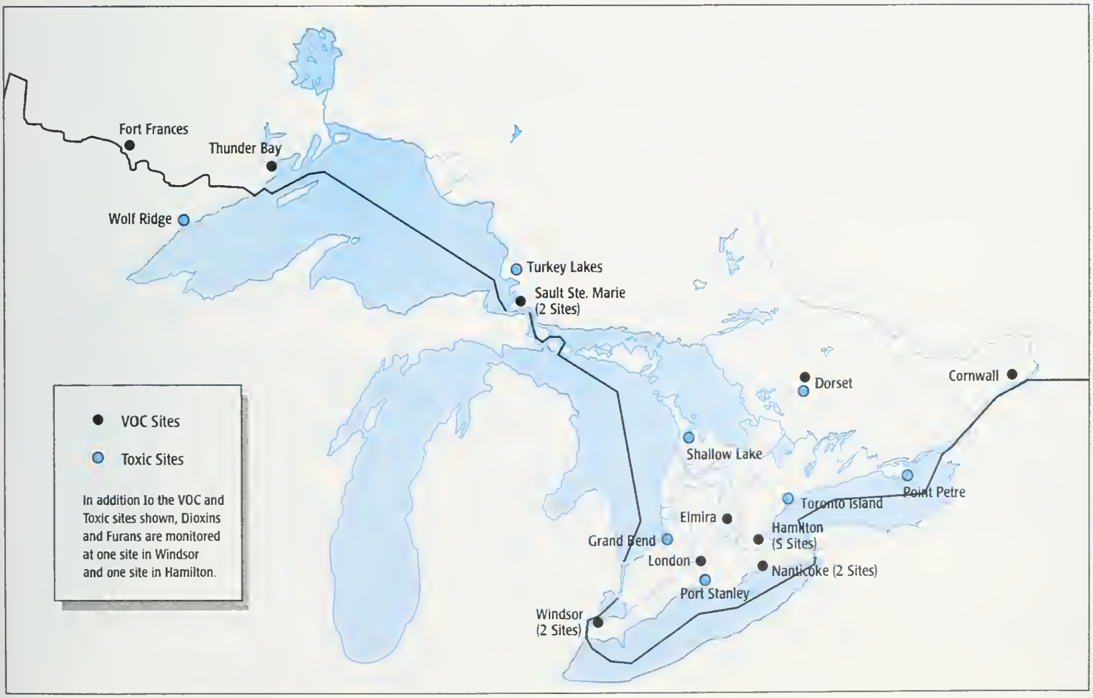
Volatile organic compounds

More than 20 VOCs are monitored in Ontario, mostly in urban and industrial areas. The concentrations are typically low, as summarized in Table 6.1. Ambient air quality criteria (AAQC) exist for a number of the VOCs, but they are in all cases substantially higher than the levels observed in the province.

As indicated in Table 6.1, the listed compounds can be classified into seven groups. The two compounds in Group I are emitted mainly from

Figure 6.1

VOC, toxic, and dioxin/furan monitoring site locations (1996)



In addition to the VOC and Toxic sites shown, Dioxins and Furans are monitored at one site in Windsor and one site in Hamilton.

Table 6.1

Median concentrations of VOCs from all sites (1990 to 1996)

Group	Compound	Median Concentration ($\mu g/m^3$)			
		Urban	Source	Suburban	Rural
I	α-Pinene	0.75	0.10	0.20	0.26
	Isoprene	0.16	0.07	0.08	0.05
II	Chloroform	0.15	0.06	0.10	0.06
	Carbon tetrachloride	0.40	0.44	0.40	0.40
	1,1-dichloroethylene	0.05	0.05	0.05	0.04
	Trichloroethylene	0.05	0.05	0.05	0.05
	1,1,1-trichloroethane	0.73	0.72	0.63	0.44
	Tetrachloroethylene	0.31	0.20	0.25	0.09
III	Para-dichloro benzene	0.05	0.05	0.05	0.05
IV	Benzene	1.40	1.70	1.11	0.40
	Toluene	3.69	2.90	2.62	0.54
	Ethyl benzene	0.62	0.43	0.50	0.10
	Ortho-xylene	0.80	0.50	0.54	0.06
	(Meta+para)-xylene	2.20	1.50	1.60	0.22
	1,2,4-trimethyl benzene	1.08	0.59	0.65	0.05
	1,3,5-trimethyl benzene	0.32	0.20	0.24	0.05
	Styrene	0.20	0.10	0.10	0.05
V	Hexane	1.13	0.95	1.00	0.26
	Cyclohexane	0.15	0.12	0.12	0.04
VI	1,3-butadiene	0.05	0.05	0.05	0.05
VII	Naphthalene	0.41	0.60	0.40	0.10

vegetation. The high α-pinene value shown for the urban sites is due to measurements made in Cornwall, where significant amounts of α-pinene are released to the atmosphere in the processing of lumber. The concentrations of isoprene are low at all sites because it reacts very rapidly in the atmosphere.

The compounds of Group II all contain chlorine, and are generally used as solvents. There are concerns that some of these compounds may be carcinogenic, or may be toxic to the central nervous system and/or the liver or kidney. However, in all cases the measured concentrations are considerably below their current AAQC. In some cases, median concentrations are at or very close to the detection limit, while others are similar to background values reported for other jurisdictions.

The sole representative of Group III also contains chlorine. It is used as a deodorant and also as a starting material in the production of other chemicals. There is some evidence of toxicity of this chemical, but the concentrations reported in Table 6.1 are also at or below the detection limit for most samples and are very much lower than the current AAQC.

Group IV compounds are benzene and several derivatives of benzene. These compounds have toxic properties, but can also be part of the formation of smog. They are emitted from automobile exhausts, by the petrochemical industry and by some other industries. The decrease in concentration of these pollutants in going from urban through source and suburban to rural measurements is consistent with the emission sources. The highest median concentration in this group is for toluene, and this value of 3.69 $\mu g/m^3$ should be compared with the current AAQC of 2000 $\mu g/m^3$. The concentrations are lower than the values reported for a number of locations in the United States (for example, the 1996 annual average benzene concentrations in California ranged from 3 to 8 $\mu g/m^3$ compared to 0.4 to 1.7 $\mu g/m^3$ in Ontario).

The two compounds in Group V are emitted by motor vehicles and are also used as solvents. These compounds may contribute to the formation of photochemical smog. Again, however, their concentrations are low in Ontario. The Group VI compound, butadiene, is known to be hazardous to human health, and is also very reactive in the formation of smog. However, its concentration in the air in Ontario is at or barely above the detection limit. Naphthalene, listed in Group VII, is used in moth balls. The AAQC for this compound is 22.5 µg/m³, about a factor of 40 to 60 higher than the reported median concentrations.

Concentration measurements have been made since 1990 for many of the compounds listed in Table 6.1. The change with time is shown for selected compounds in Figures 6.2 and 6.3. There has been a fairly steady overall downward trend for benzene, toluene and ortho-xylene (Figure 6.2).

The compounds whose concentrations are shown in Figure 6.3 are generally used as solvents for various purposes. Such solvent use is subject to increasing control in Ontario, and the result is seen in the steady downward trend for 1,1,1-trichloroethane. The other compounds show very little change over the seven years.

Persistent organic pollutants

The ministry has cooperated for several years with Environment Canada and the USEPA in monitoring concentrations of a number of POPs in the Great Lakes basin. These concentrations are measured in air (as in the case of the VOCs), and also in rain and snow. The measurements are important because a number of these chemicals find their way into lakes by being deposited from the atmosphere, rather than by direct discharge of contaminated water to the lakes or to rivers feeding the lakes.

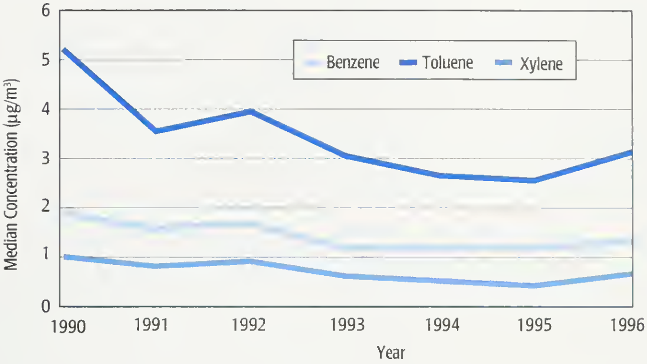
The observed concentrations are very low and there appears to be no real variation with location, even though the monitoring sites encompass both the upper and lower Great Lake regions. In fact, the concentrations of a number of the POPs are usually below the detection limit of the best analytical methods available.

Table 6.2 summarizes the observed concentrations, showing the overall median value across all sites and all years of available data. Those compounds for which the concentration was below the detection limit for 70 per cent or more of the samples are entered as blanks in the table.

As seen in Table 6.2, only three of the compounds are detectable in rain and snow samples for 30 per cent of the time or more. The first of these is hexachlorobenzene, which was used at one time as a fungicide to protect seeds but is now found only as an impurity in the manufacture of other chemicals. The other two are different forms of an insecticide. Its general use was banned several years ago, but it is still found in specialized applications, such as the treatment of head lice and scabies.

Figure 6.2

Median concentrations of Benzene, Toluene and Xylene



Detectable concentrations have been observed more frequently in the sampling of air. This is because the sensitivity is higher than for precipitation. All three of the compounds reported for precipitation are also detectable in air. In addition, similar median concentrations were found for the various chlorinated forms of benzene, which mainly have industrial uses as solvents or intermediates in the production of other chemicals.

Figure 6.3

Median concentrations of 1,1,1-Trichloroethane, Carbon Tetrachloride and 1,1-Dichloroethylene (1990-1996)

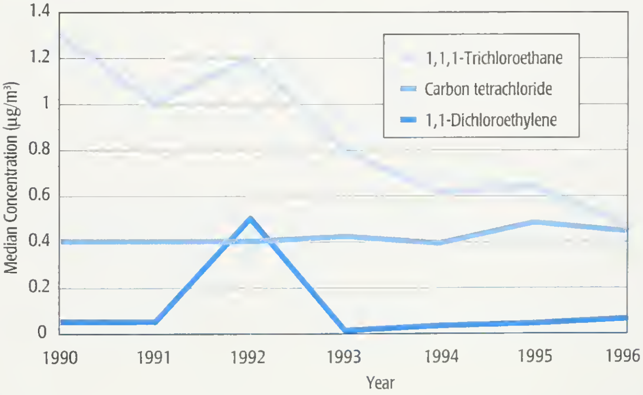


Table 6.2

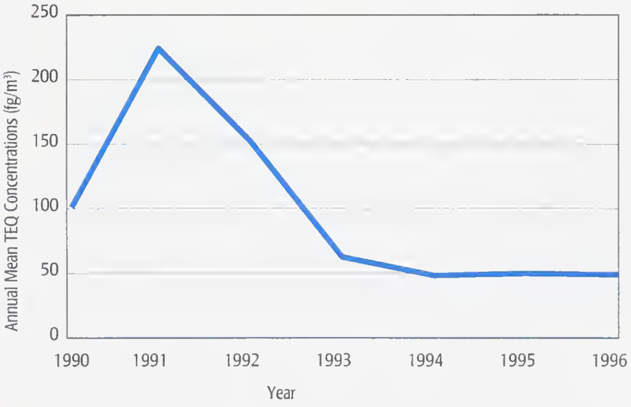
Median concentrations for persistent organic pollutants monitored in the Great Lakes toxic network

Chemical	Air Concentration (pg/m³)	Precipitation Concentration (ng/L)
Hexachlorobenzene	65.74	0.15
Heptachlor	1.14	-
Aldrin	1.06	-
Mirex	-	-
α-Hexachlorocyclohexane	71.62	0.63
β-Hexachlorocyclohexane	1.05	-
γ-Hexachlorocyclohexane	5.09	0.16
α-Chlordane	4.43	-
γ-Chlordane	5.09	-
Oxychlordane	1.07	-
p,p-DDE	1.31	-
o,p-DDT	-	-
p,p-DDD	-	-
p,p-DDT	1.06	-
Octachlorostyrene	-	-
1,2,3-trichlorobenzene	39.68	-
1,3,5-trichlorobenzene	3.06	-
1,2,4-trichlorobenzene	112.24	-
1,2,3,4-tetrachlorobenzene	40.57	-
1,2,4,5-tetrachlorobenzene	28.89	-
Pentachlorobenzene	37.21	-
Heptachlor epoxide	1.19	-
Endosulfan I	-	-
Endosulfan II	-	-
Dieldrin	1.08	-
Endosulfan sulphate	-	-
Methoxychlor	-	-

'-' indicates 70 per cent of values below detection limit.

Figure 6.4

Annual mean Dioxin/Furan levels in Windsor (1990-1996)



They are generally being phased out in North America, together with many other chlorine-containing compounds. Very low concentrations were also found for the listed pesticides. The use of these pesticides (except for methoxychlor) has been discontinued in North America. It is believed that these trace concentrations result from residues that remain in the environment, with contributions also from very long-range atmospheric transport from regions where they are still used. Methoxychlor is still in use in North America, but its concentration is below the detectable levels for more than 70 per cent of the time for both air and precipitation samples.

Dioxins and furans

Dioxins and furans are currently monitored at sites in Windsor and Hamilton. Here, rather than reporting all the different chemical forms of the compounds, the concentrations are summarized in terms of the toxic equivalence (TEQ). The TEQ is calculated by totaling the individual concentrations, allowing for the toxicity of each of the dioxins relative to the most toxic form, i.e. 2,3,7,8-TCDD.

The trend results for Windsor are shown in Figure 6.4. The 1996 levels were around 50 fg/m^3, which represents a significant decrease from the early 1990s. This decrease may be attributed to improved control technology at the nearby Detroit Greater Recovery Authority incinerator.

In comparison to Ontario's AAQC for dioxins and furans (5000 fg/m^3), the highest single TEQ in the data set for Windsor and Hamilton is 1,145 fg/m^3, or less than a quarter of the criterion. Seventy-five per cent of the data points are less than 100 fg/m^3, or one-fiftieth of the criterion. Moreover, these values have decreased with time, so it can be concluded that ambient dioxin and furan levels in Windsor and Hamilton are low relative to their AAQC.

Chapter 7

Future Directions

Since the first edition of this report in 1971, there has been consistent improvement in the province's air quality, even as the population has grown. For example, significant decreases have been achieved for sulphur dioxide, carbon monoxide, total suspended particles, nitrogen oxides and total reduced sulphur compounds.

Encouraging as this is, there is still a great deal of work to be done, and the Ontario government is directing increased emphasis to ozone and inhalable and respirable particles (PM_{10} and $PM_{2.5}$), for which recent scientific evidence suggests significant health effects.

Ground-level ozone remains a concern, as do PM_{10} levels: In 1996, there were a number of days on which PM_{10} levels exceeded a 24-hour interim PM_{10} criterion of 50 µg/m³. For ambient urban sites the highest percentage of days (11 per cent) occurred in Hamilton, a city with significant local sources, and in an area subjected to trans-boundary effect. A significant number of days of PM_{10} exceeding the interim criterion (approximately five per cent) were also noted in Windsor and London, locations strongly influenced by long-range transport and trans-boundary effect.

Data analysis strongly implicates neighbouring U.S. states as being significant contributors to high levels of fine particles and ozone in southern Ontario. The contributions from long-range transport and trans-boundary movement of air pollution and from local sources need further assessment.

Because of potential health and environmental effects of these two contaminants (key ingredients of smog), continued monitoring is required to evaluate trends and determine the effectiveness of reduction and abatement strategies.

Ontario has begun to change its existing monitoring network by deploying real-time monitors of inhalable and respirable particles. These are being phased in over the next few years. In 1996 there were six monitors of $PM_{10}/PM_{2.5}$ for which data were available. The collection and assessment of such data will allow future improvements to the Air Quality Index and Air Quality Advisory programs by including fine particles measurements as a key element, along with ozone, in the Air Quality Index network.

The Ontario government has committed itself fully to improving air quality with a series of initiatives, foremost of which is its Drive Clean program which, starting in spring 1999, will require emissions testing of vehicles, followed by repairs where necessary.

Other, ongoing, activities include:

- Ontario's Smog Plan, a government-industry partnership that commits 44 organizations to reduction of smog-causing emissions
- updating of air quality standards and regulations to make them better, clearer and stronger, including a standard for inhalable particles
- less polluting blends of gasoline mandated during the summer – resulting in 18,000 fewer tonnes of smog-causing compounds annually
- strong environmental protection measures being built into the design of a competitive electricity market
- $3 million spent since 1995 on the province's air monitoring network, as well as a new air monitoring bus
- public education, that includes Partners in Air for high school students, and Smog Rover, a mobile van that identifies significant polluting vehicles on Ontario's roads
- an ongoing campaign to persuade neighbouring U.S. states to toughen their air quality regulations – which would lessen trans-boundary pollution

Along with the contributions of concerned citizens, organizations and industries, these initiatives will go a long way toward improving the quality of Ontario's air.

Glossary

Acidic deposition
refers to deposition of a variety of acidic pollutants (acids or acid-forming substances such as sulphates and nitrates) on biota or land or in waters of the earth's surface.

Air Quality Index
real-time information system that provides the public with an indication of air quality in major cities across Ontario.

AQI station
continuous monitoring station in a built up area, used to inform the public of air quality levels on a real-time basis; station must report on at least ozone and suspended particles to be classified AQI.

Air Pollution Index
basis of Ontario's alert and control system to warn of deteriorating air quality; derived from 24-hour running averages of sulphur dioxide and suspended particles.

Ambient air
outdoor or open air.

Carcinogen
an agent that incites carcinoma (cancer) or other malignancy.

Continuous pollutant
contaminant for which a continuous record exists; effectively, pollutants that have hourly data (maximum 8760 values per year).

Continuous station
where pollutants are measured on a real-time basis and data determined hourly (as for ozone, sulphur dioxide).

Criterion
maximum concentration or level (based on potential effects)of contaminant that is desirable or considered acceptable in ambient air.

Daily pollutant
contaminant with a 24-hour or daily value (maximum 365 values per year).

Detection limit
minimum concentration of a compound contaminant that can be determined.

Fossil fuels
natural gas, petroleum, coal and any form of solid, liquid or gaseous fuel derived from such materials for the purpose of creating heat.

Gas chromatography
separation technique involving passage of a gaseous moving phase through a column containing a fixed absorbent phase; used principally as a quantitative analytical technique for volatile compounds.

Geometric mean
statistic of a data set calculated by taking the nth root of the product of all (n) values in a data set. Provides a better indication than arithmetic mean of the central tendency for a small data set with extreme values.

Global warming
long-term rise in the average temperature of the earth; principally due to an increase in the buildup of carbon dioxide and other gases.

Ground-level ozone
colorless gas formed from chemical reactions between nitrogen oxide and hydrocarbons in the presence of sunlight near the earth's surface.

Inhalable particles
represents up to 60 per cent of the total suspended particles; composed of both primary (diameter 2.6 to 10.0 microns) and fine (diameter 2.5 microns) particles; also referred to as PM_{10}.

Median
middle value of a set of numbers arranged in order of magnitude.

Monthly pollutant
contaminant for which there exists only a monthly (30-day) value (maximum 12 values per year).

Non-continuous station
station that measures pollutant concentration on a daily, six-day frequency or monthly cycle (as for total suspended particles).

Ozone episode day
a day on which widespread (hundreds of kilometres) elevated ozone levels (greater than 80 ppb maximum hourly concentration) occur simultaneously.

Particles
refers to any airborne finely divided solid or liquid material with an aerodynamic diameter smaller than 100 micrometer.

Percentile value

percentage of the data set that lies below the stated value; if the 70 percentile value is 0.10 ppm, then 70 per cent of the data are equal to or below 0.10 ppm.

Photochemical oxidant

any of the chemicals that enter into oxidation reactions in the presence of light or other radiant energy.

Photochemical reaction

chemical reaction influenced or initiated by light, particularly ultraviolet light.

Photochemical smog

see smog.

Primary pollutant

contaminant emitted directly to the atmosphere.

Respirable particles

particles smaller than about 2.5 microns in diameter, which arise mainly from condensation of hot vapors and chemically-driven gas to particle conversion processes; also referred to as $PM_{2.5}$. These are fine enough to penetrate deeply into the lungs and have the greatest health effects.

Secondary pollutant

contaminant formed from other pollutants in the atmosphere.

Smog

a contraction of smoke and fog; colloquial term used for photochemical fog, which includes ozone and other contaminants; tends to be a brownish haze.

Stratosphere

atmosphere 10 to 40 kilometres above the earth's surface.

Stratospheric ozone

ozone formed in the stratosphere from the conversion of oxygen molecules by solar radiation; ozone found there absorbs much ultraviolet radiation and prevents it from reaching the earth.

Suspended particles

particles most likely to reach the lungs (diameter less than 5-10 microns).

Total suspended particle

generic term for airborne particles including smoke, fume, dust, fly ash and pollen; approximately 0.1 to 100 microns in diameter.

Toxic deposition

absorption or adsorption of a toxic pollutant at ground, vegetative or surface levels.

Toxic pollutant

substance that can cause cancer, genetic mutations, organ damage, changes to the nervous system, or even physiological harm as a result of prolonged exposure, even to relatively small amounts.

Toxicity equivalent

toxicity equivalent of chlorinated dibenzo-p-dioxins and chlorinated dibenzofurans is calculated as follows: International toxicity equivalency factors (I-TEFs) are applied to 17 dioxin and furan isomers of concern to convert them into 2,3,7,8-TCDD (tetrachlorodibenzo-p-dioxin) toxicity equivalents. The conversion involves multiplying the concentration of the isomer by the appropriate I-TEF to yield the TEQ for this isomer. Summing the individual TEQ values for each of the isomers of concern provides the total toxicity equivalent level for the sample mixture. A table listing the 17 isomers of concern and their I-TEFs can be found in the ministry publication Environment Information – Dioxin & Furans; PIBS 681b, revised 08/91.

Troposphere

atmospheric layer extending about 10 kilometres above the earth's surface.

Abbreviations

AAQC
ambient air quality criterion

API
Air Pollution Index

AQI
Air Quality Index

AQUIS
air quality information system

B[a]P
benzo [a] pyrene

CO
carbon monoxide

CO_2
carbon dioxide

COH
coefficient of haze reported as SP

EC
Environment Canada

EMRB
Environmental Monitoring and Reporting Branch

EST
Eastern Standard Time

H_2S
hydrogen sulphide

INS
insufficient data to calculate statistic

IP
inhalable particles

LIMA
Lambton industry meteorological alert

MOE
Ministry of the Environment

NAAQS
national ambient air quality standard

NO
nitric oxide

NO_2
nitrogen dioxide

NO_X
oxides of nitrogen

O_3
ozone

OEIS
Ontario emission inventory system

PAH
polycyclic aromatic hydrocarbon

PCDD
polychlorinated dibenzo dioxins

PCDF
polychlorinated dibenzo furans

$PM_{2.5}$
particles less than 2.5 micrometers

PM_{10}
particles less than 10 micrometers

RP
respirable particles

SO_2
sulphur dioxide

SO_X
sulphur oxides

SP
suspended particles

TEQ
toxicity equivalent

TRS
total reduced sulphur

TSP
total suspended particle

USEPA
United States Environmental Protection Agency

VOCs
volatile organic compounds

$g/m^2/30$ days
grams (of contaminant) per square metre per 30-day period

kg
kilogram

kt
kilotonne

$\mu g/m^3$
micrograms (of contaminant) per cubic metre (of air)

pg/m^3
picograms, i.e. a millionth of a microgram (of contaminant) per cubic metre (of air)

fg/m^3
femtograms, i.e. a billionth of a microgram (of contaminant) per cubic metre (of air)

ppb
parts (of contaminant) per billion (parts of air)

ppm
parts (of contaminant) per million (parts of air)

Appendix 1

Highlights of the principal contaminants (1996 year-in-review)

	SO_2	SP as COH	CO	NO_2	O_3	TRS	PM_{10}
Lowest annual mean value	0.3 ppb	0.14 COH unit	< 0.1 ppm	2.7 ppb	12.2 ppb	0.1 ppb	15.8 µg/m^3
Location/ station #	Thunder Bay (63200)	North Bay (75010)	London (15025)	Dorset (49010)	Toronto (31303)	Thunder Bay (63200)	Kingston (52020)
Highest annual mean value	10.1 ppb	0.51 COH unit	1.3 ppm	33.9 ppb	33.5 ppb	3.0	27.1 µg/m^3
Location/ station #	Hamilton (29102)	Hamilton (29025)	Toronto (31303)	Toronto (31303)	Long Point (22901)	Cornwall (56068)	Hamilton (29000)
Most criterion exceedances - 1 hour	17	N/A	0	0	129	210	N/A
Location/ station #	Sudbury (77016)				Long Point (22901)	Fort Frances (62030)	
Most criterion exceedances - 24 hour	0	23	N/A	1	N/A	N/A	4
Location/ station #		Hamilton (29025)	N/A	York (36030)	N/A	N/A	Hamilton (29000)
# of stations exceeding 1-hour AAQC	13	N/A	0	0	40	22	N/A
# of stations exceeding 24-hour AAQC	0	16	N/A	1	N/A	N/A	5
Highest measured 1-hour value	724.0 ppb	4.8 COH unit	23 ppm	171.0 ppb	129.0 ppb	276.0	349.0 µg/m^3
Location/ station #	New Sudbury (77075)	Hamilton (29102)	Hamilton (29000)	York (36030)	Long Point (22901)	Fort Frances (62047)	Windsor (12016)
Highest measured 24-hour value	83.7 ppb	2.0 COH unit	N/A	100.4 ppb	88.0 ppb	51.6 ppb	105.9 µg/m^3
Location/ station #	Sarnia (14064)	Hamilton (29531)	N/A	York (36030)	Long Point (22901)	Fort Frances (62047)	Windsor (12016)
Total number of sites	52	34	20	28	43	34	5

Appendix 2

Highlights of the total suspended particles (TSP), metals in TSP and sulphate and nitrate in TSP (1996 year-in-review)

	TSP	Pb	Cr	Fe	Mn	Ni	Cu	V	SO_4^{2-}	NO_3^-
Lowest annual mean value	20.4 μg/m^3	30.01 μg/m^3	0.002 μg/m^3	0.2 μg/m^3	0.004 μg/m^3	0.002 μg/m^3	0.01 μg/m^3	0.001 μg/m^3	3.9 μg/m^3	1.1 μg/m^3
Location/ station #	Fort Frances (62032)	several	several	Longwoods (15009)	Corunna (14030)	Longwoods (15009)	several	several	Thunder Bay (63121)	Thunder Bay (63121)
Highest annual mean value	90.1 μg/m^3	0.08 μg/m^3	0.062 μg/m^3	5.6 μg/m^3	0.228 μg/m^3	0.014 μg/m^3	0.29 μg/m^3	0.009 μg/m^3	17.3 μg/m^3	5.9 μg/m^3
Location/ station #	Hamilton (29113)	Toronto (31058)	Hamilton (29011)	Windsor (12038)	Hamilton (29011)	Windsor (12038)	Mississauga (46117)	Windsor (12038)	Hamilton (29025)	Windsor) (12015)
Percentage of samples above 24-hour AAQC	32.7	37.5	14.7	N/A	1.8	0	0	0	0	N/A
Location/ station #	Sault Ste. Marie (71042)	Mississauga (46047)	Thorold (27052)		Hamilton (29025)					
# of stations exceeding 24-hour AAQC	38	3	1	N/A	1	0	0	0	N/A	N/A
# of stations exceeding 1-year AAQC	18	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Highest measured 24-hour value	455 μg/m^3	5.3 μg/m^3	6.2 μg/m^3	6.2 μg/m^3	4.4 μg/m^3	1.4 μg/m^3	1.60 μg/m^3	0.18 μg/m^3	57.1 μg/m^3	18.5 μg/m^3
Location/ station #	Hearst (72083)	Mississauga (46047)	Thorold (27052)	Sault Ste. Marie (71042)	Hamilton (29025)	Copper Cliff (77070)	Toronto (31058)	Sarnia (14064)	Windsor (12007)	Hamilton (29102)
Total number of sites	79	39	33	33	33	33	33	33	20	20

Appendix 3

Highlights of the 24 hour PM$_{10}$, select metals in PM$_{10}$ and sulphate in PM$_{10}$ (1996 year-in-review)

	PM$_{10}$	Fe	Mn	Cu	SO_4^{2-}
Lowest mean value	13.6 μg/m^3	0.15 μg/m^3	0.004 μg/m^3	0.003 μg/m^3	1.4 μg/m^3
Location/ station #	Sudbury (77326)	Cornwall (56051)	Fort Frances (62135)	Fort Frances (62135)	Thunder Bay (63201)
Highest mean value	42.0 μg/m^3	2.22 μg/m^3	0.111 μg/m^3	0.027 μg/m^3	4.7 μg/m^3
Location/ station #	Sault Ste. Marie (71342)	Sault Ste. Marie (71342)	Hamilton (29313)	Sudbury (77326)	Windsor (12507)
Percentage of samples above 24-hour AAQC	32.7	N/A	N/A	N/A	N/A
Location/ station #	Sault Ste. Marie (71342)	N/A	N/A	N/A	N/A
# of stations exceeding 24-hour AAQC	19	N/A	N/A	N/A	N/A
# of stations exceeding 1-year AAQC	N/A	N/A	N/A	N/A	N/A
Highest measured 24-hour value	164.0 μg/m^3	43.0 μg/m^3	1.6 μg/m^3	5.0 μg/m^3	38.3 μg/m^3
Location/ station #	Sault Ste. Marie (71342)	Sault Ste. Marie (71342)	Hamilton (29313)	Copper Cliff (77570)	Hamilton (29300)
Total number of sites	23	23	23	23	23

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